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JOURNAL OF PALEONTOLOGY

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SOME JURASSIC AND CRETACEOUS CORALS FROM NORTHERN MEXICO

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ABSTRACT—Description of one new species, *Astrocoenia kellumi*, from the Upper Jurassic La Casita formation of Durango, and three new species and one variety: *Montlivaltia coahuilensis*, *M. burckhardti*, *Axosmilia mexicana*, and *Stephanocoenia guadalupae minor*, from several localities in the Neocomian and Aptian of Coahuila, Durango, and Sonora. A new Lower Cretaceous species of *Placocoenia* is indicated but not named, and *Isastrea whitneyi*, previously described from the Glen Rose formation of central Texas, is recognized from the Aptian of Coahuila.

INTRODUCTION

THE CORALS described below were collected several years ago during the course of a coöperative study by geologists of several universities of the structure and stratigraphy of northern Mexico (Kellum, Imlay, and Kane, 1936, p. 971). They were turned over to the writer by R. W. Imlay; recently L. B. Kellum sent several additional specimens not included in the first lot. The writer expresses his thanks to Drs. Imlay and Kellum for permission to study and describe these somewhat mixed lots. He is further indebted to Dr. Kellum for comments on the introductory part of the manuscript. All specimens are in the University of Michigan Museum of Paleontology (U.M.). References to the stratigraphy of the localities where corals have been found are given below.

UPPER JURASSIC LOCALITY

La Casita formation (*Kimmeridgian*).—Two and one-half miles southwest of Las Cuevas Ranch, Durango, northern Mexico (Kellum, 1936, p. 1054–1055, 1067, collection A-13; Imlay, 1938, p. 1679, figure 4, and p. 1881):

Astrocoenia kellumi Wells, n. sp.

This seems to be the first scleractinian coral to be described from the Mexican Jurassic, although another species of this genus, *A. maloniana*, was long ago described by Vaughan (1905, p. 34) from the coeval Malone formation of western Texas. There are reef corals, as yet undescribed, in the lower Oxfordian limestones (Zuloaga, La Gloria) in north-central Mexico (Burckhardt, 1930, p. 51, 61, 65, 82, 86).

LOWER CRETACEOUS LOCALITIES

Carbonera formation (*middle Valanginian*).—Two miles southwest of Las Cuevas, Durango (Imlay, 1940, p. 129, 138):

Astrocoenia hispaniensis Imlay 1940
Placocoenia n. sp.
Montlivaltia coahuilensis Wells, n. sp.

Northwest end of Sierra de Hispaña, about 1 mile northeast of La Goma station, Durango (Kellum, 1936, p. 1068—Collec-

tion K-97; Imlay, 1940, p. 129):
Montlivaltia coahuilensis Wells, n. sp.

Barril Viejo shale (*lower Hauterivian*).—Los Vagos, Potrero de Oballos, eastern Coahuila (Imlay, 1940, p. 127, fig. 3):
Montlivaltia coahuilensis Wells, n. sp.
Montlivaltia burckhardti Wells, n. sp.
Axosmilia mexicana Wells, n. sp.

Barril Viejo, southeast of Cuatrocienegas, eastern Coahuila (Imlay, 1940, p. 127, fig. 3):
Montlivaltia burckhardti Wells, n. sp.
Axosmilia mexicana Wells, n. sp.

Cuchillo formation (*Trinity = U. Aptian—L. Albian*).—Outlier of Sierra del Venado, Coahuila (Kelly, 1936, p. 1027):
Isastrea whitneyi Wells 1932

Lower part of Cuchillo formation (basal conglomerate), Sierra de Acatita, at head of canyon east of Acatita ranch, southwestern Coahuila (Kelly, 1936, pl. 7, section east of Cañon Pesuna):
Stephanocoenia guadalupae Wells var. *minor* n. var.
Isastrea whitneyi Wells 1932

"*Trinity*" (*upper Aptian—lower Albian*).—One-fourth of a mile west of Rancho de King, Cañon Sta. Rosa, 3 miles southeast of El Tigre, Sonora:
Stephanocoenia guadalupae minor Wells, n. var.

FAUNAL RELATIONS

The Cretaceous species listed above represent two distinct faunas. One, occurring in the Carbonera formation and Barril Viejo shale, of Valanginian-Hauterivian age, consists mostly of a few solitary types, which lived scattered on shallow banks or shoals in the Coahuila peninsular area under environmental conditions unsuited to the growth of colonial reef-builders. It is not related to the penecontemporaneous reef coral fauna of the Tehuacan region of southern Mexico described by Felix (1891), although the two lived in the same embayment. Nor is it related to the later reef fauna of the Trinity of northern Mexico and central Texas. The other coral fauna, from the Trinity of Sonora and the Cuchillo formation of Coahuila, as yet very imperfectly known, seems to be a slightly modified and diminished extension of the reef coral fauna (Wells, 1932) of the lower Glen Rose formation of central Texas.

UPPER JURASSIC CORAL

Genus ASTROCOENIA Milne-Edwards and Haime, 1848

ASTROCOENIA KELLUMI Wells, n. sp.

Plate 1, figure 1

Corallum cerioid, nodular or subspherical, 5 cm. or so in height and breadth. Corallites prismatic, united by closely fused walls, which are commonly 0.5 mm. or more in thickness. Internal diameter of corallites from 1.5 to 2.5 mm., averaging 1.75 mm. Septa moderately thick, laterally strongly spinose, normally arranged in three complete cycles (12/12), the first two cycles being nearly equal and extending to the columella, to which they are fused by expanded inner trabecular extensions. The 12 septa of the third cycle are thin and rudimentary. Columella a thin style. Endothecal dissepiments well developed.

Locality and material.—La Casita formation, Upper Jurassic (Kimmeridgian—Portlandian), 2.5 miles southwest of Las Cuevas ranch, Durango. One specimen (holotype—U.M. 15969), collected by Kellum and Jones (A-13).

Remarks.—The exterior of the single specimen is weathered, and the description is based upon thin sections of the interior. In some corallites only 9, 10, or 11 larger septa are developed and reach the columella, so that the septal arrangement is 9/9, 10/10, or 11/11, but these are exceptional. In some cases the columella appears to be free of the septa or with only a few septa attached to it, but this is due to the septa not being continuously connected to the columella but only at points of trabecular emergence along the inner septa margins. The trabeculae, as is usual in the Astrocoeniidae, are relatively few and far apart (0.2–0.3 mm., transverse to corallite). The projection of these trabeculae from the inner part of the upper margins of the septa produces in some cases the appearance of pali, a feature found in several species of *Astrocoenia* (*A. whitneyi*, *A. cesaredensis*, etc.).

Few species of this genus are yet known from the American Jurassic: *A. maloniana* Vaughan (1905, p. 34, pl. 2, figs. 1–3) from the Malone formation (Portlandian) of western Texas; *A. hyatti* Wells (1942a, p. 1, figs. 1–6) from the upper Sundance formation (Kimmeridgian) of Wyoming; *A.?* sp.

Wells (1942b, p. 128, pl. 21, fig. 5) from the subsurface Smackover limestone (Argovian) of Arkansas. *A. maloniana*, to which *A. kellumi* is closely allied, is distinguished by its octameral or decameral septal arrangement, weakly developed dissepiments, and less rudimentary secondary septa. The other two both differ by their ramose growth-form.

A. kellumi does not seem to be related to any of the European Jurassic *Astrocoeniae*, most of which have ramose rather than more or less massive growth forms. The widespread *A. bernensis* has much smaller (1.5 mm.) corallites and fewer (about 20) septa. Both *A. matheyi* Koby (1885, p. 293, pl. 86, figs. 7, 8) from the White Corallian of Switzerland and *A. dubia* Koby (1885, p. 294, pl. 89, figs. 2, 2a) from the Sequanian of Switzerland, have larger (3–3.5 mm.) corallites.

LOWER CRETACEOUS CORALS

Genus STEPHANOCOENIA Milne-Edwards and Haime, 1848

STEPHANOCOENIA GUADALUPAE MINOR Wells, n. var.

Plate 1, figures 2–4

Like *S. guadalupae* Wells (1932, p. 235, pl. 32, figs. 8, 9; pl. 39, fig. 3) in all respects, except that the calices are less protuberant, nearly flush, and have an internal diameter of 1.5 mm.

Localities and material.—"Trinity" (upper Aptian—lower Albian), one-quarter mile west of Rancho de King, Cañon Sta. Rosa, 3 miles southeast of El Tigre, Sonora, Mexico; one specimen (holotype—U.M. 23339) collected by R. W. Imlay, 1938. Lower Cuchillo formation (Aptian), Sierra de Acatita, east of Acatita ranch, southwestern Coahuila; one specimen (U.M. 15993) collected by L. B. Kellum, 1931.

Localities of S. guadalupae.—Basal Glen Rose (lower Albian), Guadalupe river, Comal county, central Texas (type locality). Barranquin formation (upper Aptian—lower Albian), La Borracha island, northeastern Venezuela.

Remarks.—The specimen from Sonora is a rounded nodular corallum about the size of one's fist; that from Coahuila is imperfect but seems to represent a small nodular corallum a few centimeters across with several low proliferations. In both, the corallites are more closely appressed than in the Glen Rose form, rarely being as much as 0.75 mm. apart—about half the maximum separation in *S. guadalupae*. This is not so significant, however, as the size of the corallites, for in the Recent *S. michelini* of the West Indies the corallites may either be separated or with fused walls in the same corallum, but with nearly uniform corallites.

Genus ISASTREA Milne-Edwards and Haime, 1851

ISASTREA WHITNEYI Wells

Plate 2, figures 1–3

Isastrea whitneyi Wells, 1932, Jour. Paleontology, vol. 6, 245, pl. 39, figs. 4, 5.

Localities and material.—Lower Cuchillo formation (Aptian), Sierra de Acatita, at head of canyon east of Acatita ranch, Coahuila; one specimen (U.M. 15992), collected by L. B. Kellum, 1931. Upper Cuchillo formation (L. Albian?), outlier of Sierra del Venado, Coahuila; two specimens, both pieces from the same large corallum (Kelly, 1936, p. 1027) (U.M. 15786), collected by W. A. Kelly, 1933. Lower Glen Rose formation (lower Albian), Comal, Blanco, and Hays counties, central Texas (Wells, 1932).

Remarks.—The specimens from the upper Cuchillo are badly preserved, being crumbly and saccharoidal, with the exterior not shown at all and the mural structures internally almost completely destroyed by recrystallization. They are from a large, mollusc-riddled, massive corallum. A thin section from one fortunately shows the significant internal structures. Colony formation was by intratentacular budding, the permanent condition tending to be monocentric. Corallites prismatic, with thin but solid, fused walls. Diameter from 3 mm. in monocentric corallites to 3×6 mm. in budding corallites. Number of septa ranging from 40 or 45 to a little more than 50. Septa relatively thin, composed of simple trabeculae, subequal, imperforate, uniting cyclically, with the larger ones meeting a central trabecular tangle, which forms a parietal columella. A few peripheral synapticulae. All these structures correspond almost exactly with typical *I. whitneyi* from the Glen Rose, a transverse section of which is introduced for comparison (pl. 2, fig. 3).

The other specimen, from Sierra de Acatita, is a small pedunculated head 6 cm. across and about 5 cm. high, fairly well preserved externally, but almost completely destroyed internally by lithophagous molluscs and recrystallization. The internal structures are those of *Isastrea*. Corallites prismatic, with well-defined common walls and well-excavated polygonal calices averaging 5 mm. in diameter. The septa number between 45 and 55, uniting, with distinctly beaded upper margins. Internally the septa are slightly perforate and seemingly thin. The reference of this specimen to *I. whitneyi* is not completely certain—the corallites are slightly larger, the septa lighter and slightly more numerous. It may represent a subspecies.

Genus MONTLIVALTIA Lamouroux, 1821

MONTLIVALTIA COAHUILENSIS Wells, n. sp.

Plate 1, figure 5; plate 2, figures 4–6

Corallum solitary, patellate, with flat to convex, epithecate base, circular to subovate in outline. Basal epitheca thin, strongly wrinkled by growth lines. Calyx shallow, with elongate axial depression. Septa strongly exsert, numerous, relatively thin, strongly dentate, nonuniting, more or less regularly arranged in at least five complete cycles in mature individuals (12/12/24/48), with the sixth developed in systems bordering the ends of the axial depression (96–160+ septa). First two cycles extending to and bordering the axial depression, with swollen inner ends. Some specimens indicate the possible presence of lobate inner lower cycle septal ends. Other cycles successively shorter and lower. Columella absent, or very weakly developed by union of inner ends of first and second cycle septa. Endotheca cellular, developed only in basal portions of corallites, forming a weak parathecal wall.

DIMENSIONS

Specimen	Diameters	Height	Septa
	mm.	mm.	
23340 (holotype)	37×40	15+	160+
23341	28×31	7+	96+
20909	17×17	5+	96
20909	19×19	7	96+

Localities and material.—Barril Viejo shale (lower Hauterivian), Los Vagos, Potrero de Oballos, eastern Coahuila; one specimen (holotype—U.M. 23340), collected by R. W. Imlay. Carbonera formation (middle Valanginian), about 1 mile northeast of La Goma station, Durango; 10 specimens (U.M. 20909), collected by L. B. Kellum (K-97), 1932. Carbonera formation, 2 miles southwest of Las Cuevas, Durango; one specimen and a limestone block with many fragmentary and partially complete individuals (U.M. 23341), collected by R. W. Imlay, 1937.

Remarks.—The holotype from the Barril Viejo shale is much larger than most of the specimens from the Carbonera formation localities, but fragments of very large individuals associated with others grading down to a diameter of 5 mm., with about 40 septa, in the limestone block from the Carbonera referred to above, indicate the identity of the specimens. Nine of the 10 specimens from marls at the La Goma locality are small, nearly of equal size, averaging about 17 mm. across, while the tenth, a fragment, indicates a corallum at least 38 mm. along the longer axis.

Patelliform species of *Montlivaltia* are not common in the Cretaceous. *M. coahuilensis* may be related to *M. icaunensis* d'Orbigny (de Fromentel, 1867, p. 315, pl. 43, fig. 2; pl. 78, fig. 3 (?); pl. 81, figs. 1 (?), 2) from the Hauterivian of Chenay (Yonne) and Morancourt (Haute-Marne), which has

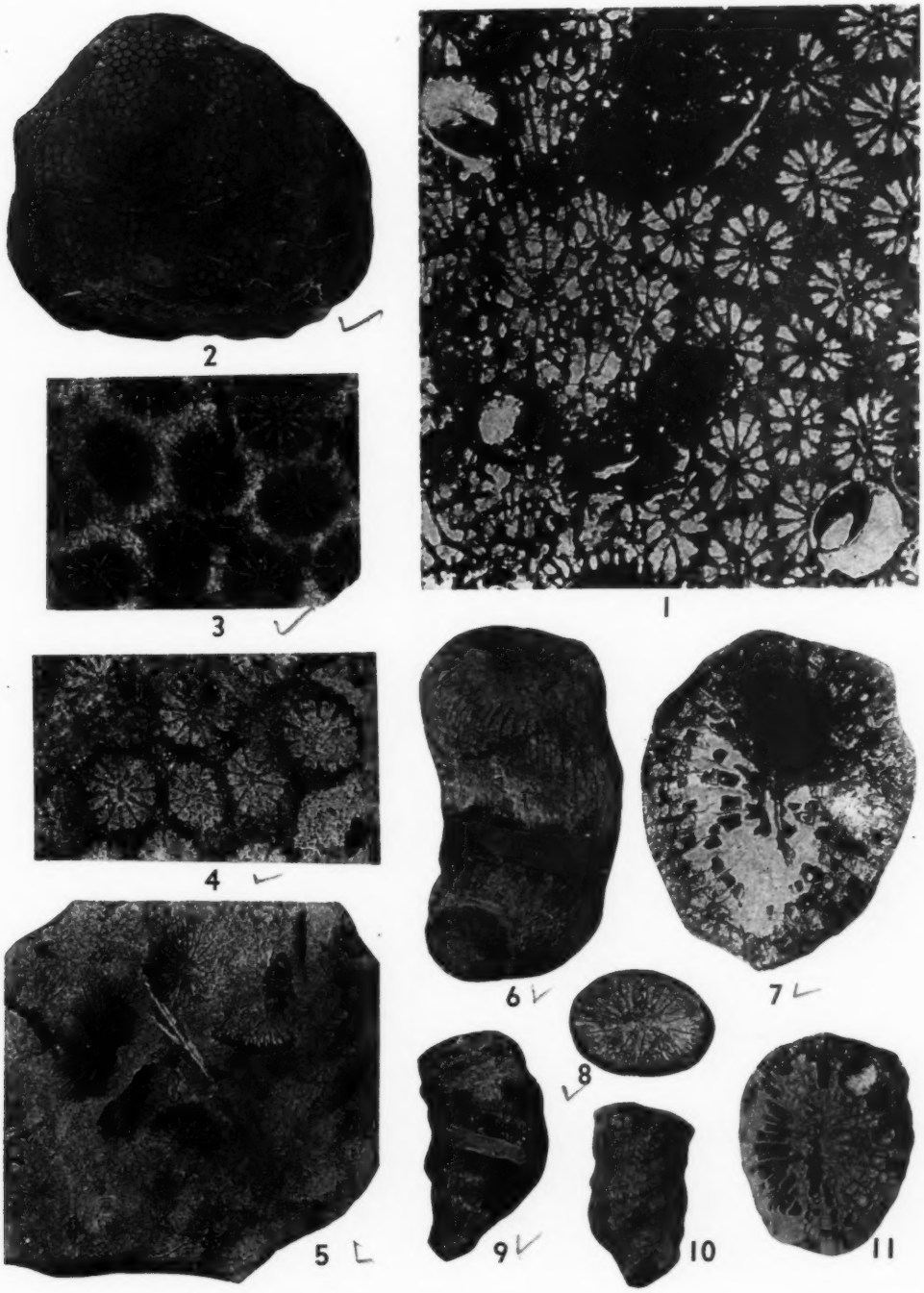
EXPLANATION OF PLATE 1

FIGS. *1*—***Astrocoenia kellumi*** Wells, n. sp. Holotype (U.M. 15969), transverse thin section, ×6. Note perforations by lithophagous molluscs. (p. 2)

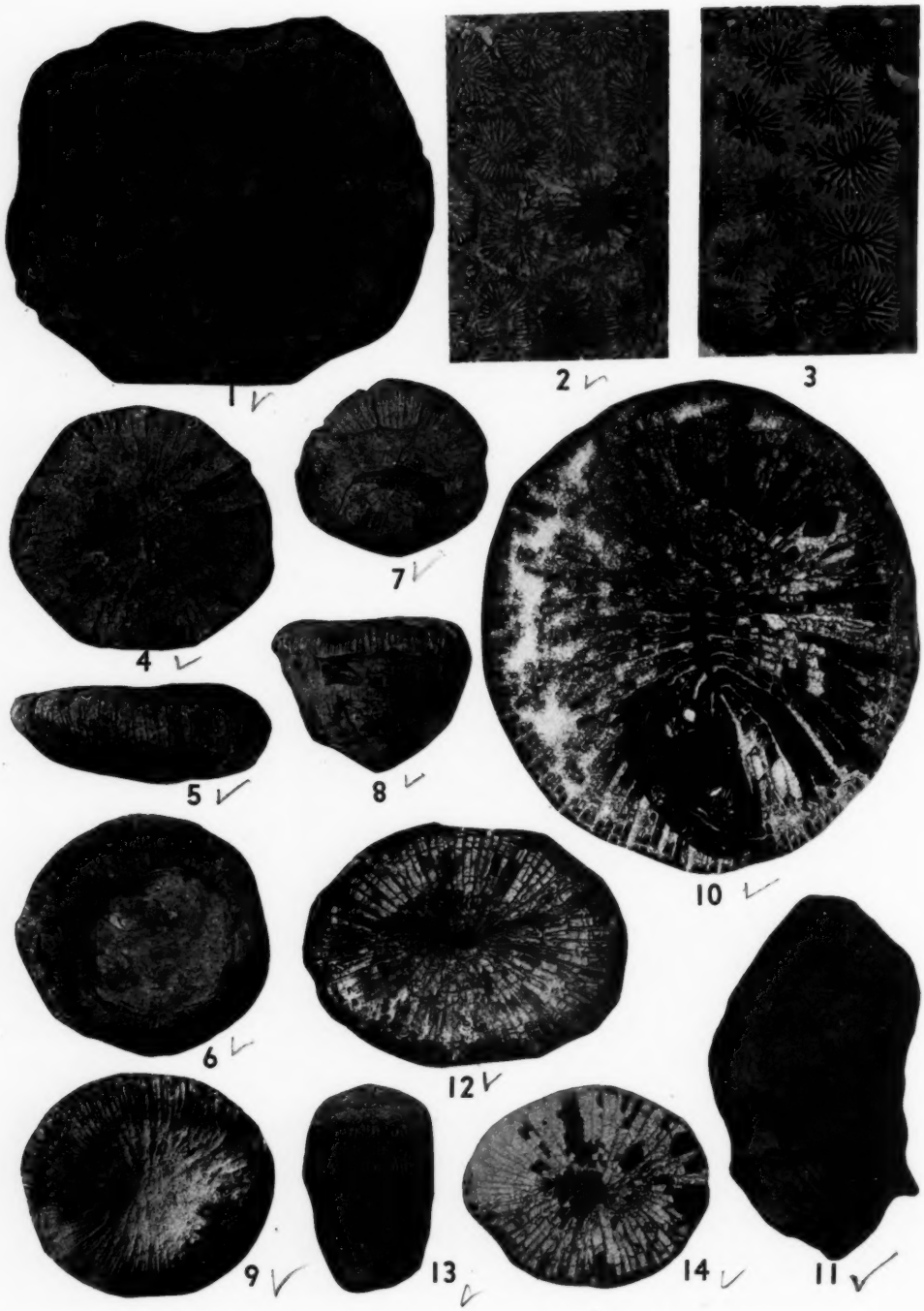
2–4—***Stephanocoenia guadalupae minor*** Wells, n. var. *2, 3*, Holotype (U.M. 23339), lateral aspect of corallum, ×½, and transverse thin section, ×6. *4*, Worn calices of specimen (U.N. 15993) from Coahuila, ×6. (p. 3)

5—***Montlivaltia coahuilensis*** Wells, n. sp. Limestone block (U.M. 23341) from Carbonera formation with many more or less complete individuals, ×⅓. (p. 4)

6–11—***Axosmilia mexicana*** Wells, n. sp. *6, 7*, Paratype (U.M. 23348), lateral aspect, ×1, and transverse thin section, ×2. *8, 9*, Holotype (U.M. 23348), calicular and lateral aspects, ×1. *10, 11*, Lateral aspect of specimen (U.M. 23350) from Barril Viejo, ×1, and transverse thin section, ×2. (p. 6)



Wells, Jurassic and Cretaceous Corals



Wells, Mexican Cretaceous Corals

about the same maximum diameter, elongate calicular fossette or axis, and the same number and arrangement of septa, but which seems to have become somewhat turbinate in the mature stage, rather than remaining patellate. Similarly maturely subturbinate is *M. pateriformis* (Michelin) (de Fromentel, 1867, p. 316, pl. 43, fig. 2), a French Cenomanian species. *M. subpateriformis* de Fromentel (1867, p. 322, pl. 77, fig. 2), also from the Hauterivian at Morancourt, is more uniformly patellate than *M. pateriformis*, and may be allied to *M. coahuilensis*, the only apparent difference being that in the French form only the 12 septa of the first two cycles seem to extend to the axis.

MONTLIVALTIA BURCKHARDTI Wells, n. sp.
Plate 2, figures 7–14

Corallum solitary, turbinate, curved, fixed by a small expanded base, above which the corallum flares rapidly. Complete, wrinkled epitheca originally present but commonly eroded away by postmortem abrasion. Calyx shallow, axial depression or fossa elongate. Septa exsert, numerous, relatively thin, strongly dentate, nonuniting, more or less regularly arranged in at least five complete cycles (24/24/48) with the sixth cycle septa present in as many as half the systems (96+48=144). Septa of first three cycles extending to and bordering the axial depression, those of the first two (12) with strongly swollen inner margins. Other cycles successively shorter and thinner. Wall largely parathecal. Costae highly developed, strongly beaded on edges, thin, subacute, unequal cyclically. Columella absent. Endotheca cellular, most abundant axially and peripherally.

DIMENSIONS

Specimen	Diameters	Height	Septa
23345	31×34	?	144
23346	ca. 28×35	20+	ca. 144
23342 (cotype)	27×30	25	96
23343 (cotype)	21×25	40	100+
23344	21×25	50	ca. 96

Localities and material.—Barril Viejo shale (Hauterivian): Barril Viejo, southeast of Cuatrocienegas, Coahuila, six specimens (U.M. 23344–46). Potrero de Oballos, eastern Coahuila; two specimens (cotypes, U.M. 23342–43).

Remarks.—The essential difference between this species and *M. coahuilensis* is in the growth form, which is turbinate instead of patellate. In other respects they are alike. De Fromentel (1867, p. 316) included under *M. icaunensis* from the Hauterivian of the southeastern border of the Paris basin two different growth forms, one patellate (op. cit., pl. 42, fig. 2; pl. 81, fig. 2), like *M. coahuilensis*, the other turbinate (op. cit., pl. 73, fig. 3; pl. 81, fig. 1), like *M. burckhardti*. Study of large suites of the French, as well as of the new Mexican forms, is necessary to establish whether in each case individual or specific variation is involved. *M. rugulosa* Koby (1898, p. 90, pl. 22, figs. 8–10) from the Valanginian of Switzerland, has much the same growth form as *M. burckhardti*, but the calicular fossette is not elongated.

Genus PLACOCOENIA d'Orbigny, 1849
PLACOCOENIA, n. sp.

Locality and material.—Carbonera formation (middle Valanginian), 2 miles south of Las Cuevas, Durango; one specimen (U.M. 23347), collected by R. W. Imlay, 1937.

EXPLANATION OF PLATE 2

FIGS. *1–3*—*Isastrea whitneyi* Wells, *1*, Calcicular aspect of specimen (U.M. 15992) from lower Cuchillo formation, ×1. *2*, Transverse thin section of specimen (U.M. 15786), from upper Cuchillo formation, ×3. *3*, Transverse thin section of paratype from lower Glen Rose formation, central Texas, ×3. (p. 3)

4–6—*Montlivaltia coahuilensis* Wells, n. sp. Holotype (U.M. 23340), calicular, lateral, and basal aspects, ×1. (p. 4)

7–14—*Montlivaltia burckhardti* Wells, n. sp. *7*, *8*, Cotype (U.M. 23342), calicular and lateral aspects, ×1. *9*, *10*, Calyx, ×1, and transverse thin section, ×2, of specimen (U.M. 23345), from Barril Viejo. *11*, Lateral aspect of specimen (U.M. 23344) from Barril Viejo, ×1. *12*, Transverse thin section of other cotype (U.M. 23343), ×2. *13*, *14*, Lateral aspect, ×1, and transverse thin section of specimen (U.M. 23346) from Barril Viejo, ×2. (p. 5)

Remarks.—The single specimen is too poorly preserved to be named at this time. It represents a small nodular corallum about 5 cm. high, composed of placoid corallites from 3.5 to 4.5 mm. in diameter and 2–3 mm. apart, united by costae. Calices slightly protuberant, shallow, with three complete cycles of thin, subequal septa (24) arranged 6/6/12, and a thin but well-developed lamellar columella, to which the six primary septa are loosely attached.

Placocoenia is essentially an Upper Cretaceous montastreid, but a few species, not well established, are known from the Lower Cretaceous: *P. sparsa* (Trautschold) (Solomko, 1887, p. 23, pl. 1, fig. 5, as *Heliocoenia sparsa*), from the Neocomian of Crimea, *P. decamera* and *P. uhligi* Volz (1903, p. 15, pl. 3, figs. 5–12) from the Neocomian of Bukowina, and *P. neuquensis* Gerth (1928, p. 6, pl. 1, fig. 5), from the Aptian of Argentina. *P. sparsa* and *P. decamera* have decamerally arranged septa; *P. uhligi* is octameral; and *P. neuquensis* is hexameral with small (2–3 mm.), subcerioid corallites.

Genus AXOSMILIA Milne-Edwards and Haime, 1848

Pleurosmilia DE FROMENTEL, 1856, Soc. géol. France Bull., sér. 2, t. 113, p. 853.

AXOSMILIA MEXICANA Wells, n. sp.

Plate 1, figures 6–11

Corallum solitary, free in mature stages, turbinate, strongly curved or cornute, externally epithecate, noncostate. No mural structure other than epitheca. Calyx elongate-oval, with elongate, deep fossette. Septa all free on inner edges, nonexsert, thin, nondentate, arranged in four complete cycles with the fifth developed in most of the systems with occasional septa of the sixth cycle. Septa of first cycle extending nearly to the axial space, into which one of them lying in the plane of the longer calicular axis projects to form a prominent lamellar columella. Septa of higher cycles regularly shorter, those of the fifth very thin and small. Endotheca well developed.

DIMENSIONS

Specimen	Diameters	Height	Septa
	mm.	mm.	
Holotype	15×20	35	100±
Paratype	23×27	52	100±
23350	13×16	20+	50+

Localities and material.—Barril Viejo shale (Hauterivian): Potrero de Oballos, eastern Coahuila, two specimens (holotype—U.M. 23348; paratype—U.M. 23349), collected by R. W. Imlay. Barril Viejo, southeast of Cuatrocienegas, Coahuila; two specimens, one doubtfully included in this species (U.M. 23350).

Remarks.—The two specimens from Barril Viejo are small but appear to be mature. They may represent a subspecies or even a distinct species, but more specimens are needed to establish such a separation.

This genus has been previously reported in America by the writer as *Axosmilia* sp. (Wells, 1932, p. 233, pl. 30, fig. 1) from the lower Glen Rose formation of central Texas, which is much larger and proportionally fewer septa; and *A. craginiana* (Wells, 1933, p. 142, pl. 4, figs. 23, 24) from the Fredericksburg (middle Albian) of central Texas, which is a larger, less cornutiform species with fewer septa for its size. Amongst Lower Cretaceous *Axosmilia* from elsewhere *A. mexicana* does not find any close allies.

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ALLEGHENY FOSSIL INVERTEBRATES FROM EASTERN OHIO—NAUTILOIDEA

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ABSTRACT—Two collections of nautiloid cephalopods from the Vanport, Hamden, and Washingtonville members of the Allegheny series (Pennsylvanian) of eastern Ohio are described. Seventeen species and varieties representing 10 genera are recognized, and six fragmentary species representing possibly two other genera were also studied. Ten of the forms are believed to belong to heretofore undescribed species or varieties. Several of the genera and most of the species are reported from the Pennsylvanian strata of Ohio for the first time.

ACKNOWLEDGMENTS

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INTRODUCTION

The invertebrate fauna of the Allegheny series of eastern Ohio has received only casual and sporadic attention from paleontologists. Morton (1836) named and crudely illustrated some Pennsylvanian fossils from eastern Ohio in an appendix to Hildreth's paper on the bituminous coal deposits of the Ohio valley. Some of Morton's specimens came from fossiliferous members of the Allegheny series at Putnam Hill, Zanesville, Ohio. This was the initial contribution to the study of the Allegheny fauna of eastern Ohio.

Meek (1875) and Whitfield (1893) described in the reports of the Second and Third Geological Survey of Ohio some Pennsylvanian invertebrate fossils from Ohio, some of which undoubtedly came from the Allegheny series. At about the same time Herrick (1887) was carrying on his Flint Ridge faunal studies, and he described a few species from the Vanport limestone at that locality. The total number of Allegheny species studied by these several paleontologists is rather small.

The largest addition that has been made to the known list of Allegheny fossils was the result of a stratigraphic error. Morningstar (1922) in her bulletin on the Pottsville fauna of Ohio identified a large list of fossils from the so-called MacArthur limestone of Lawrence, Scioto, Jackson, Vinton, Hocking, Perry, Muskingum, and Coshocton counties and from the "Black" flint of Jackson and Vinton counties. At that time the MacArthur and "Black" flint members were believed to be members of the Pottsville series lying above the Upper Mercer flint and below the base of the Allegheny series. The MacArthur member is now known to be the Putnam Hill limestone, which is the lowest fossiliferous member of the Allegheny

series. The "Black" flint has been named the Zaleski flint and is also a member of the Allegheny series as shown in table 1. Raymond (1910) has also identified 46 Allegheny species from the Vanport limestone of Ohio is divided in ascending order into the Pottsville, Allegheny, Conemaugh, and Monongahela series. The outcrop of the Allegheny series extends in a northeast-southwest belt across the southeastern part

TABLE 1. COMPOSITE STRATIGRAPHIC SECTION OF THE ALLEGHENY SERIES IN OHIO

Slightly modified after Stout in Bownocker and Dean's (1929) Analyses of Ohio Coals. The marine limestone, shale, and flint members are marked by an asterisk and those supplying fossils for this study are italicized.

Member	General description	Thickness Feet	Thickness Inches
Upper Freeport, No. 7	Coal, Patchy	3	0
	Clay and shale	7	0
Upper Freeport	Limestone and marly shale	2	0
Bolivar	Coal, local, thin	0	3
Bolivar	Clay, flint and plastic	5	0
Upper Freeport	Shale or sandstone	33	0
Lower Freeport	Coal, patchy	1	0
	Clay, impure	2	6
Lower Freeport	Limestone, local	1	0
Lower Freeport	Shale or sandstone	25	0
Upper Kittanning	Coal, local	1	0
	Shale and sandstone	10	0
**Washingtonville*	Shale, marine	4	0
Middle Kittanning, No. 6	Coal, persistent	4	0
	Clay, siliceous	3	6
Salem	Limestone, impure, local	0	6
	Shale, with red kidney ore	10	0
Strasburg	Coal, local	0	6
Oak Hill	Clay, flint and plastic	4	0
	Shale, siliceous	3	0
**Hamden*	Limestone, unsteady, marine	4	0
Lower Kittanning, No. 5	Coal	2	4
	Clay, plastic	5	0
Lawrence	Coal, shaly, local	0	4
	Clay, flint and plastic	6	0
Kittanning	Shale and sandstone	8	2
Ferriferous	Ore, irregular	0	8
**Vanport*	Limestone, marine	6	0
Scrubgrass	Coal, local	0	6
	Shale, carbonaceous	5	0
Clarion, No. 4a	Coal, patchy	4	0
	Clay, flint and plastic	5	0
Canary	Ore, local	0	6
Clarion	Sandstone, irregular	10	6
Winters	Coal, local	1	0
*Zaleski	Flint, impure, marine	1	0
Ogan	Coal, local	1	0
	Shale and sandstone	25	0
**Putnam Hill*	Limestone, marine	4	0
Brookville, No. 4	Coal, steady	2	0
	Total average thickness	212±	0

western Pennsylvania. Raymond's specimens were not collected in Ohio, but they are from localities so near the Ohio border that they constitute a valuable reference to the present study.

The Pennsylvanian system of eastern of Ohio from Columbiana and Mahoning counties on the northeast to Scioto and Lawrence counties on the southwest as shown in figure 1. According to the Geological Survey of Ohio the area of outcrop is approximately 2,600 square miles; and the

FIG. 1—Map of Ohio showing the outcrop areas of the Allegheny series and the localities from which collections of fossil nautiloids were made.

thickness, varying from 175 to 280 feet, averages about 212 feet. Most of the thickness consists of nonmarine shale and sandstone, but there are numerous other freshwater members of clay, coal, and limestone and marine members of limestone, shale, flint, and iron ore. The complete composite stratigraphic succession of the Allegheny series in Ohio is shown in table 1.

Table 1 includes 13 coal beds, five marine members of limestone, flint, or shale, two marine iron-ore members, and four named sandstone members. The complete succession is not present in any locality, and probably no member is continuous across the State. The only cyclothem that approaches theoretical completeness is associated with the Middle Kittanning coal.

From the base upward the marine members, excepting the iron-ore members, are the Putnam Hill limestone, the Zaleski flint, the Vanport limestone, the Hamden limestone, and the Washingtonville shale. The Putnam Hill member is fairly continuous in distribution from Jackson County in southern Ohio at least as far northeast as Stark

County. In lithologic character this member varies from bedded limestone to limestone nodules embedded in calcareous shale. The Zaleski member is black flint or siliceous limestone, and its known outcrop is limited to Vinton and Jackson counties. The Vanport limestone is recognized at many localities from Lawrence County in the south to Mahoning County in the northeast. Its lithology varies widely from limestone and calcareous shale to siliceous limestone and flint. The Hamden member is best developed in northeastern Ohio, but it is present as far south as Vinton County. At most places it is nodular limestone embedded in fossiliferous shale, but locally it is bedded limestone or iron ore. The fossiliferous Washingtonville shale is either carbonaceous or simply argillaceous and extends in discontinuous patches along the outcrop belt of the Allegheny series across the State.

In the summer of 1932 the writer made an extensive collection of fossils from the Vanport, Hamden, and Washingtonville members in the Lisbon quadrangle, which includes parts of Columbiana and Mahoning counties, and he has continued collecting to the present in the same area. Additional collecting from these three members and also from the Putnam Hill member has been done as far southwest as Muskingum County. Some fossils collected by Mr. E. J. Bognar from the Vanport member at Bolivar, Ohio, were made available for study by the Department of Geology, Ohio State University.

The exact correlation of the Allegheny series of Ohio will undoubtedly be more definitely determined when its fauna is more completely known. As far as known the Allegheny fauna is dominantly molluscan in its number of species, although the brachiopods far exceed the molluscs in number of individuals.

At present the Allegheny nautiloid cephalopods are not very useful for more exact age determination and correlation. Almost without exception the known genera and species have a long stratigraphic range or are herein described as new species. These species with long stratigraphic ranges in the Pennsylvanian system of North America are *Pseudorthoceras knoxense*, *Mooreoceras normale*, *Ephippioceras ferratum*, *Liroceras liratum*, and *Metacoceras perelegans*. The newly described species will be of use only when their geographic and stratigraphic distribution has been determined. For half a dozen or more species better material will have to be collected before positive specific identification will be possible. Table 2 shows the known distribution of nautiloid cephalopods in the Allegheny marine members of Ohio.

The restricted Allegheny species that appear to be most reliable at present are three species of brachiopods: *Mesolobus mesolobus euampygus*, *Marginifera muricatina*, and *Neospirifer cameratus*. In the Mid-Continent region these three species are restricted to the Des Moines series.

The varieties or species of *Mesolobus* are probably the most useful for correlation because of their ubiquitous occurrence in large numbers. The Des Moines series is known as the zone of *Mesolobus*, and it has been shown by recent studies that the striated varieties of *Mesolobus* occur in older strata than the unstriated varieties. In Ohio the specimens from the Pottsville series and possibly from the lower fossiliferous members of the Allegheny series are striated and are representatives of *Mesolobus mesolobus striatus* as proposed by Weller and McGehee (1933). Specimens of *Mesolobus* from the Hamden and Washingtonville members and possibly from the Vanport member are unstriated and are referred to *Mesolobus mesolobus euampygus*. No species of Mesolobus is known from the Conemaugh series of Ohio. In Illinois the unstriated forms of *Mesolobus* of the *decipiens-euampygus* group are reported by Weller and McGehee (1933) to be common in the Liverpool cyclothem and to extend upward into the Gimlet cyclothem. Savage has stated at an earlier date (1924) that *Chonetes mesolobus euampygus* is one of the guide fossils to the Carbondale formation of Illinois. The unstriated varieties of *Mesolobus mesolobus* are also common and characteristic in the Marmaton group of the Des Moines series of Iowa, Missouri, Kansas, and Oklahoma. Kelly (1930) has identified specimens closely resembling *Chonetes mesolobus euampygus* near Grand Ledge and along Six-mile Creek, New Haven Township, Shiawasee County, Michigan.

Marginifera muricatina is also locally

TABLE 2. STRATIGRAPHIC DISTRIBUTION OF NAUTILOID CEPHALOPODS IN THE ALLEGHENY SERIES OF EASTERN OHIO

Species	Member	Putnam Hill	Zaleski	Vanport	Hamden	Washington-ville
Pseudorthoceras knoxense		×	—	×	×	×
Mooreoceras normale		—	—	—	×	—
Brachycycloceras ohioense, n. sp.		—	—	—	×	—
Poterioceras subellipticum		—	—	×	—	—
Poterioceras curtum		—	—	×	×	—
Ephippioceras ferratum		—	—	—	×	—
Liroceras liratum		—	—	—	×	—
Temnocheilus quinqueliratus, n. sp.		—	—	×	—	—
Temnocheilus medioventralis, n. sp.		—	—	—	×	—
Temnocheilus sp.		—	—	—	×	—
Metacoceras tricarinatum, n. sp.		—	—	×	—	—
Metacoceras tricarinatum parvinodosum, n. var.		—	—	×	—	—
Metacoceras perelegans		—	—	?	×	—
Metacoceras lambi, n. sp.		—	—	—	×	—
Metacoceras sp. 1		—	—	—	×	—
Metacoceras sp. 2		—	—	—	×	—
Parametacoceras? sp.		—	—	×	—	—
Domatoceras obsoletum, n. sp.		—	—	—	×	—
Domatoceras shepherdi, n. sp.		—	—	—	×	×
Domatoceras sp.		—	—	×	—	—
Solenochilus bognari, n. sp.		—	—	×	—	—
Solenochilus greenensis, n. sp.		—	—	—	×	—
Nautiloid undetermined		—	—	×	—	—

abundant and particularly so in the Hamden member of the Lisbon quadrangle and possibly in the Vanport member in the same area. *Neospirifer cameratus* is much less common than the varieties of *Mesolobus mesolobus* and *Marginifera muricatina* and is on that account much less useful as a guide fossil.

SYSTEMATIC DESCRIPTIONS

Genus PSEUDORTHOCERAS Girty

PSEUDORTHOCERAS KNOXENSE (McChesney)

Plate 3, figures 5–9

1860. *Orthoceras knoxensis* McChesney, Descriptions of new Paleozoic fossils, p. 69.

Pennsylvanian: Danville, Springfield, Peoria; and Knox County, Illinois.

EXPLANATION OF PLATE 3

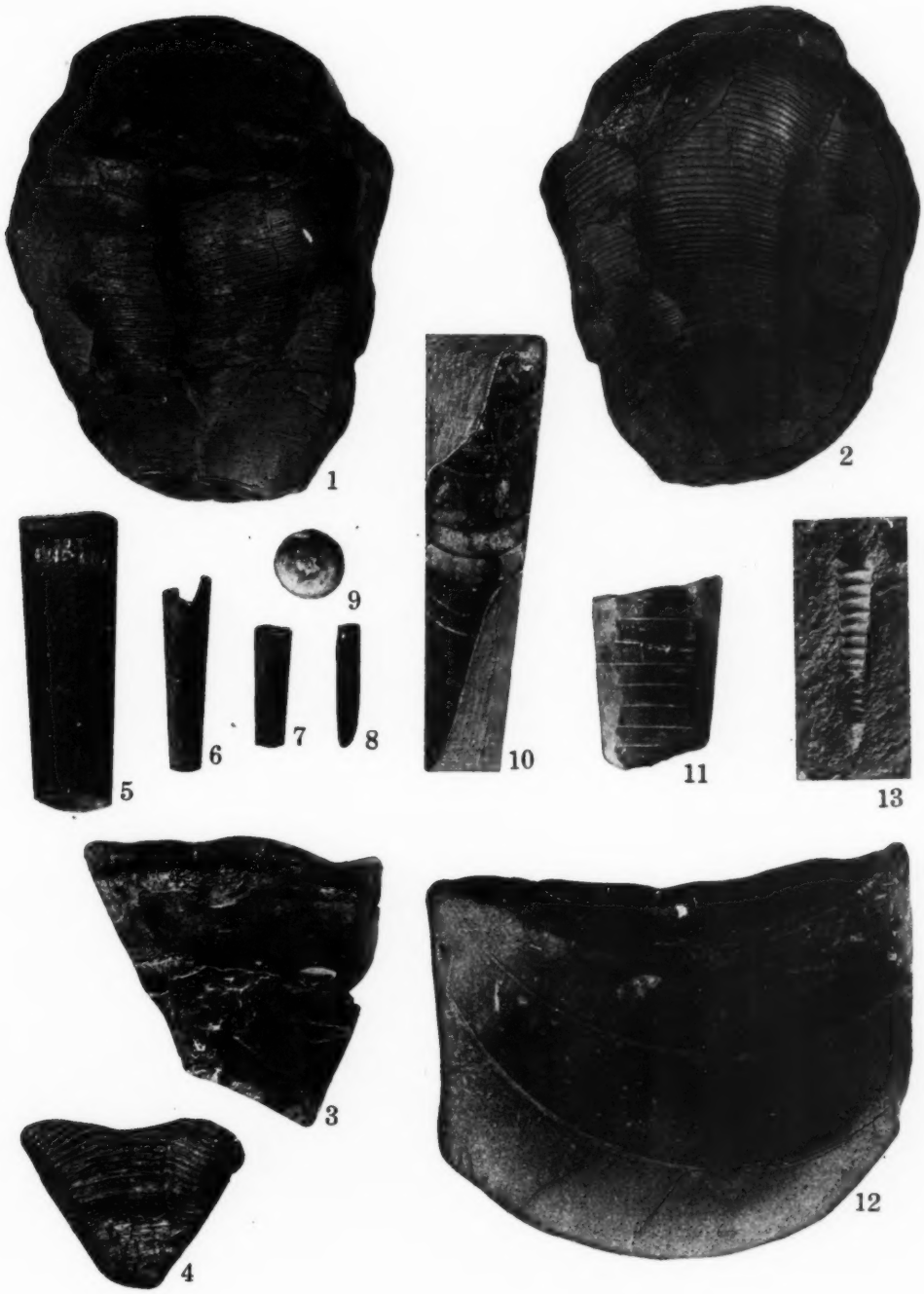
FIGS. *1–4*—*Poterioceras* sp. aff. *P. curtum* (Meek and Worthen). *1, 2*, Dorsal and ventral views of a crushed specimen, ×1. *3*, Lateral view of an exfoliated, incomplete phragmacone, ×1. *4*, Ventral(?) view of a crushed fragment, slightly more than ×1. All specimens from the Vanport limestone, section 7, Green Township, Mahoning County, Ohio. (p. 17)

5–9—*Pseudorthoceras knoxense* (McChesney). *5–8*, Various views of fragmentary specimens, ×2. *9*, View of septum, ×2. All specimens from the Vanport limestone, section 7, Green Township, Mahoning County, Ohio. (p. 12)

10, 11—*Mooreoceras normale* Miller, Dunbar, and Condra. *10*, Polished section of a specimen showing siphuncle and septa, ×1½, from the Hamden limestone, section 33, Green Township, Mahoning County, Ohio. *11*, View of exfoliated, fragmentary specimen, slightly more than ×1, from the Hamden limestone, exact locality within Lisbon (Ohio) quadrangle unknown. (p. 14)

12—*Mooreoceras normale* Miller, Dunbar, and Condra? Polished section of a portion of a large specimen showing septal spacing and position of siphuncle, ×1, from the Hamden limestone, section 33, Green Township, Mahoning County, Ohio. (p. 14)

13—*Brachycycloceras ohioense* Sturgeon, n. sp. Part of exfoliated test from holotype showing the annulations, slightly less than ×2, from the Hamden limestone, section 33, Green Township, Mahoning County, Ohio. (p. 14)



Sturgeon, Pennsylvanian Nautiloidea

Sturgeon, Pennsylvanian Nautiloidea

1911. *Pseudorthoceras knoxense* Girty, New York Acad. Sci. Annals, vol. 21, p. 143.
Wewoka formation: Wewoka and Coalgate quadrangles, Oklahoma.

1915. *Pseudorthoceras knoxense* Girty, U. S. Geol. Surv. Bull. 544, pp. 227–234, pl. 27, figs. 1–6.
Wewoka formation: Wewoka and Coalgate quadrangles, Oklahoma.

1922. *Pseudorthoceras knoxense* Morningstar, Ohio Geol. Surv., ser. 4, Bull. 25, pp. 268–269.
Lowellville, Boggs, and Lower Mercer members, Pottsville series and Putnam Hill (MacArthur) member, Allegheny series, Ohio.

1933. *Pseudorthoceras knoxense* Miller, Dunbar, and Condra, Nebraska Geol. Surv., ser. 2, Bull. 9, pp. 81–85, pl. 1, figs. 4–9.
Pennsylvanian: Widespread.

The present understanding of *Pseudorthoceras knoxense* is due to the rather detailed description made by Girty, who in 1911 applied McChesney's specific name to specimens from Oklahoma and placed them in his newly established genus *Pseudorthoceras*. Miller, Dunbar, and Condra have subsequently added information to our knowledge of this species, and as a result most of its physical features are well known. A brief summary of the diagnostic characteristics of this species follows.

Conch orthoceraconic or slightly cyrtoceraconic, i.e., straight except for the slightly curved apical portion; long, slender, gradually and regularly expanding orad; circular in cross section. Test thin and smooth externally; internal mold of the phragmacone also smooth except for the transverse circular sutures. The septa are simple saucer-shaped discs, moderately convex apicad, and somewhat irregularly spaced; two to five of them occupying a distance equal to the diameter of the conch. Siphuncle small, central or nearly so in position; its segments expanded within the camerae into cylindrical, fusiform, or subspherical shapes; these variations sometimes occurring in the same individual. Septal necks short, strongly recurved; connecting rings contact only the septal necks. Internal walls of the camerae and in some specimens also the walls of the siphuncle lined by secondary lamellar deposits. Nature of the living chamber unknown.

Remarks.—This common Pennsylvanian species is easily recognized by its small size, smooth surface, slightly curved apical portion of the conch, central or slightly subcentral siphuncle, and the peculiar lamellar deposits lining the camerae. The other common straight species of the genus *Mooreoceras* can be differentiated from this species by the absence of lamellar deposits in the camerae, the more ventrad position of the siphuncle, and the pyriform segments of the siphuncle.

The specimens under consideration agree with the published descriptions of *Pseudorthoceras knoxense* and are undoubtedly representatives of that species. Some of the specimens retain the slightly curved apical portion of the conch; others were sectioned to show the secondary lining of the camerae and the structure of the siphuncle, which in some is slightly eccentric in position.

Occurrence.—Fragmentary specimens of this species were collected from the Hamden and Washingtonville members at many localities within the Lisbon quadrangle and from the Vanport member at an abandoned mine on the N. Weingart farm, east-central

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EXPLANATION OF PLATE 4

FIGS. *1*—*Poterioceras subellipticum* Miller and Unklesbay? Lateral view of the specimen, slightly less than ×1, from the Vanport limestone, Bolivar, Ohio. (p. 16)

2–4—*Ephippioceras ferratum* (Cox). *2*, Polished section of an immature specimen showing siphuncle and septa, ×2. *3*, Ventral view of an exfoliated, immature specimen, less than ×2. *4*, Dorsal view of a large incomplete specimen, ×1. All specimens from the Hamden limestone; *2* and *4* from section 19, Green Township, Mahoning County, Ohio, and *3*, from section 33, Green Township, Mahoning County, Ohio. (p. 18)

5—*Temnocheilus* sp. Septal (apical) view of specimen somewhat greater than ×1, from the Hamden limestone at an unknown locality within the Lisbon (Ohio) quadrangle. (p. 23)

6–9—*Liroceras liratum* (Girty). *6*, Polished specimen showing the siphuncle and septa, ×1½, from the Hamden limestone, section 19, Green Township, Mahoning County, Ohio. *7*, Lateral view of a small fragmentary specimen, ×2, from the Hamden limestone, section 33, Green Township, Mahoning County, Ohio. *8*, *9*, Dorsal and ventral views of an incomplete specimen, ×1, from the Hamden limestone at an unknown locality within the Lisbon (Ohio) quadrangle. (p. 19)

part, section 7, Green Township, Mahoning County (also within the Lisbon quadrangle) and from the same member in an abandoned strip mine 2½ miles west of Canfield, Canfield Township, Mahoning County. Morningstar found that specimens are common in the Putnam Hill (MacArthur) limestone of southeastern Ohio. Other paleontologists report this species to be widespread both geographically and stratigraphically in the Pennsylvanian of North America and also to occur possibly in the Upper Carboniferous of Europe.

Repository.—The figured specimens are in the Geological Museum, Ohio State University, Columbus, Ohio, no. 18701.

Genus MOOREOCERAS Miller, Dunbar, and Condra

MOOREOCERAS NORMALE Miller, Dunbar, and Condra

Plate 3, figures 10–12

1933. *Mooreoceras normale* Miller, Dunbar, and Condra, Nebraska Geol. Surv., ser. 2, Bull. 9, pp. 87–89, pl. 2, figs. 5–7. Pennsylvanian: Widespread.

The features of this species are well known from the readily available work by Miller, Dunbar, and Condra, and hence only the more important characteristics are summarized here.

Conch medium to large, long orthoceracone, expanding gradually and regularly orad; subcircular in cross section. Test moderately thick and ornamented externally by numerous fine, inconspicuous, sinuous growth lines and fine, straight longitudinal lines. Internal mold smooth except for the sutures and a faint longitudinal ridge on both the dorsal and ventral surfaces. The septa are simple, saucer-shaped discs, moderately convex apicad; about five occurring in a distance equal to the diameter of the phragmacone; sutures transverse to the long axis of the conch and slightly sinuous. Siphuncle situated between the center of the conch and the ventral wall, narrow at its passage through the septa and expanded within the camerae. Septal necks short and distinctly recurved; connecting rings expanded, contacting only septal necks; siphuncular segments pyriform in shape.

Remarks.—About a dozen specimens in the collection at hand seem to be conspecific with this species. All but two have a conch diameter of 15 mm. or less, and nearly every specimen is merely a portion of the phragmacone. One sectioned and polished specimen shows a siphuncle characteristic in position and structure for *Mooreoceras normale*. The ratio of septal spacing to the diameter of the conch varies from 4:1 to 6:1. The specimens with the more closely spaced septa possibly ought to referred to *Mooreoceras normale angusticameratum* Miller, Dunbar, and Condra. The only other apparent difference between these specimens and the type specimens of *M. normale* is that the faint longitudinal ridge is present on only one side of the internal mold. This absence is probably the result of poor preservation.

In addition to the small specimens there are two large ones attaining a maximum diameter of at least 60 and 65 mm., respectively, that possibly should be referred to the species *Mooreoceras normale*. The larger of these is a gerontic individual with a ratio of septal spacing to the diameter of the shell of about 14:1. In all other determinable measurements these two specimens have about the same ratios that characterize smaller specimens of *Mooreoceras normale*. Even larger specimens of this species than the two under consideration are reported by Miller and Owen from the Cherokee formation of the Mid-Continent region.

Occurrence.—Hamden limestone specimens were collected from mine refuse heaps in sections 19 and 33, Green Township, Mahoning County and sections 14 and 32, Salem Township, Columbiana County.

Repository.—Geological Museum, Ohio State University, Columbus, Ohio, nos. 18704, 18705, and 18706.

Genus BRACHYCYCLOCERAS Miller, Dunbar, and Condra

BRACHYCYCLOCERAS OHIOENSE Sturgeon, n. sp.

Plate 3, figure 13, text figure 2

The Hamden limestone has yielded a few specimens belonging to an undescribed species of the genus *Brachycycloceras*. All but one are merely exfoliated portions of the shell or external casts and molds. The holotype, which is nearly complete apicad and which may or may not be complete orad, has a length of 14 mm. and a maximum diameter of about 3.5 mm.

The preserved portion of the conch is long, slender, straight, and rather gradually expanding orad except in the extreme apicad portion, where in a distance of 2.5 to 3 mm. the diameter of the phragmacone expands rapidly to an approximate diameter of 1.9 mm. This rapidly expanding apical portion subtends an angle of approximately 38°, while the gradually expanding remainder of the conch forms an angle of about 8°. There is no indication of a flare or constriction at the adoral extremity, but complete adult conchs may possibly possess either of those features.

The outer surface of the conch is marked by abrupt, narrowly rounded, transverse annulations that are separated by much wider, almost flattened, concave areas. The exact pattern of these transverse markings is unknown, but they may be slightly sinuous in their course around the conch. The spacing of the annulations is somewhat variable and becomes much greater as the aperture is approached. Near the apicad end of the holotype the first prominent annulations are about 0.5 mm. apart, while those 10 to 12 mm. nearer the aperture are more than 1 mm. apart. On the fragments of the largest specimens the maximum spacing of the annulations is about 1.3 mm. apart. The average height of the annulations is much less than the distance between adjacent ones, not exceeding 0.25 mm., some being even less than 0.1 mm. The rapidly expanding apical portion of the conch appears to be smooth, but under the lens faint annulations can be seen apicad as far as the conch is preserved.

In addition the surface is marked by numerous fine transverse lirae that are separated by sulci that are about as deep and wide as the lirae are high and wide. These lirae appear to be present on all parts of the conch including the rapidly expanding apical portion and at the juncture between the rapidly and regularly expanding portions of the conch about 20 lirae are present between the crests of two adjacent annulations. The internal mold appears to be marked only by the transverse annulations and the sutures.

The septa are rather strongly convex apicad, with the greatest convexity between the center and one side of the conch; they are somewhat oblique to the long axis of the conch, presumably with the dorsal side being farthest orad. They are 0.7 mm. to 0.9 mm. apart where the conch has a diameter varying from 2.25 mm. to 3 mm., which is a ratio of the diameter of the phragmacone to septal spacing of about 1:3. There is no diminution in the septal spacing orad. The curvature of the septa varies between 0.35 mm. and 0.45 mm. where the conch's diameter is 2.2 mm. to 2.6 mm. or a ratio of about 1:6. The orad one-third or more of the conch is nonseptate, a fact which indicates a rather large living chamber, provided, of course, that some of the septa have not been completely destroyed. The siphuncle, which is small at its passage through the septa, is located about midway between the center and one side—presumably the venter. The short septal necks extending apicad about one-fifth of the distance to the next septum are slightly recurved. The connecting rings are not preserved.

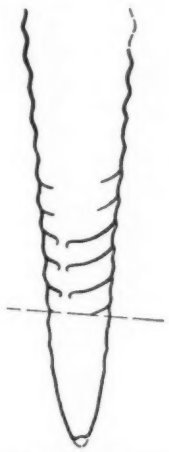


FIG. 2—*Brachycycloceras ohioense* Sturgeon, n. sp. A diagrammatic longitudinal section drawn from the holotype, the adoral three-fourths of which was sectioned and polished. The obliquity and the spacing of the septa and the position of the siphuncle are shown in the sectioned part, ×2.

Remarks.—The distinctive features of this species are the oblique septa, the fairly

smooth and rapidly expanding apical portion of the conch, and the subcircular cross section of the conch. *Brachycycloceras normale* Miller, Dunbar, and Condra from the Pennsylvanian of Oklahoma and Texas is a rather large species with an indicated apical angle of about 20°. *B. crebricinctum* (Girty) from the Wewoka formation of Oklahoma and *B. kentuckiense* Miller, Dunbar, and Condra from the Pennsylvanian of Kentucky have flaring apertures and other differences in size, cross section, and rates of expansion of conchs. *B. longulum* Miller and Owen from the Cherokee of Missouri has a slightly larger angle of expansion, more closely spaced annulations, and transverse septa.

Occurrence.—The holotype is from the Hamden limestone in the Salem Coal Company's mine, southwest quarter, section 33 Green Township, Mahoning County.

Repository.—Geological Museum, Ohio State University, Columbus, Ohio, no. 18707.

Genus POTERIOCERAS McCoy
POTERIOCERAS SUBELLIPTICUM Miller and Unklesbay?
Plate 4, figure 1

1942. *Poteriŏceras subellipticum* Miller and Unklesbay, The Cephalopod fauna of the Conemaugh series in western Pennsylvania, pp. 135–136, pl. 2, fig. 4; pl. 4, fig. 4. Pennsylvanian: Argentine member of the Wyandotte limestone, Louisville, Nebraska.

This species is represented by only one fragmentary and poorly preserved internal mold that shows part of the phragmacone and the adapical part of the living chamber. The phragmacone is incomplete apicad and has nine or ten camerae preserved. The preserved portions of the phragmacone and the living chamber have lengths of 85 mm. and 40 mm. respectively. The width of the conch at the contact between the living chamber and the phragmacone is about 75 mm., and its present height at the same place is between 55 and 60 mm., which is less than the original maximum height because of dorsoventral flattening.

The conch is large, breviconic, cyrtoceraconic, subconic in shape, regularly and moderately expanding in size throughout the preserved portion. The conch's cross section is now elliptical to subelliptical in outline, but the elliptical character may be largely due to dorsoventral compression of the conch during fossilization. Although the conch is more broadly rounded dorsally and ventrally than it is laterally, these surfaces may have been almost equally rounded during life. The exogastric curvature of the conch is confined to the apicad portion of the phragmacone, the remainder of the conch's length being straight or nearly straight. Since only a small portion of the living chamber is preserved and none of the aperture, their features cannot be determined. Likewise the nature of the apex cannot be observed.

The test is entirely exfoliated, and hence its nature is unknown. The interior mold, which was much distorted and somewhat marred during fossilization, was apparently smooth originally except for the sutures and the broad, shallow, transverse constriction on the dorsal side of the living chamber. This constriction, which lies about 25 mm. orad to the last suture, can be detected only on the dorsal surface, and even there its full width is not preserved because the remainder of the living chamber is destroyed laterally, ventrally, and orad to the constriction.

On the mold of the interior the sutures are obliterated except on the orad portion of the phragmacone. The last four septa as the living chamber is approached are 8, 11, and 15 mm. apart, and the ratio of septal spacing to the present width of the conch is about 6:1. The wider spacing of the adoral septa indicates an immature individual. Since the conch is distorted, the suture pattern probably differs considerably from the original. It is now sinuous and slightly oblique orad from the venter, but presumably the general pattern is preserved. There is a median, ventral, shallow, rounded lobe flanked on each side by a corresponding saddle, and on each flank there is an asymmetric, shallow, rounded lobe. The sutures are nearly straight across the dorsum and swing apicad at the dorsolateral zones to form a very broad, shallow, dorsal saddle. The nature and position of the siphuncle are unknown.

Remarks.—This species is probably closely related to or conspecific with *Poterioceras subellipticum* described by Miller and Unklesbay from the Argentine limestone near

Louisville, Nebraska. The incomplete and poor preservation of the Ohio specimen makes comparison difficult, but certainly the two specimens are very similar as far as can be determined. A similar dorsal transverse constriction near the aperture such as is present on the Ohio specimen probably is present in other species of *Poterioceras* but is seldom preserved or observed. It is possible that the Ohio specimen, if it were complete and not distorted, might show affinities to *P. curtum* (Meek and Worthen). The other species of *Poterioceras* from the Pennsylvanian of North America probably warrant no comparison with the specimen at hand.

Occurrence.—E. J. Bognar collected this specimen from the Vanport limestone in the pit of the Bolivar Clay Product Company, Bolivar, Ohio.

Repository.—Geological Museum, Ohio State University, Columbus, Ohio. no. 18702.

POTERIOCERAS sp. aff. P. CURTUM
(Meek and Worthen)
Plate 3, figures 1–4

1860. *Cyrtoceras curtum* Meek and Worthen, Acad. Nat. Sci. Philadelphia Proc., p. 468. Pennsylvanian: Grayville, Illinois.
1866. *Cyrtoceras (Aploceras) curtum* Meek and Worthen, Illinois Geol. Survey, vol. 2, p. 388, pl. 30, figs. 1a–c. Upper Pennsylvanian: Grayville, Illinois.

The shell is large, breviconic, cyrtoceraconic, rapidly expanding, subconical to subpyramidal. The conch is flattened laterally and broadly rounded dorsally and ventrally on the orad portions, and the dorsolateral and ventrolateral shoulders are obtusely rounded. The dorsal surface is more broadly rounded than the ventral, and the flattened flanks converge somewhat ventrally. The dorsoventral and lateral diameters of the conch are subequal, with the greatest distance between the dorsolateral shoulders. The largest specimen has a maximum width of about 69 mm. and an estimated maximum height of about 55 mm. The greatest preserved length of any specimen is about 70 mm., and that specimen is incomplete at both ends.

The test is variable in thickness, usually thick, attaining a maximum of 2 to 3 mm. The surface is typically marked by numerous transverse, deep, narrow sulci, which are separated by broad, flat lirae whose apicad margin tends to slope rather gradually into the adjacent sulcus and whose orad margin tends to slope abruptly into the sulcus on that side. The width of the lirae is variable, being wider than the sulci on all portions of the conch except apicad on the dorsal side. Toward the apicad end of one specimen the sulci are 0.47 mm. apart and near the adoral end about 0.32 mm. apart, while the maximum spacing of the sulci between is approximately 1.42 mm. The transverse markings are broadly convex orad on the venter, oblique apicad at the ventrolateral shoulders, transverse on the sides, slightly oblique apicad on the dorsolateral shoulders, and slightly concave orad or nearly straight on the dorsum. The sulci are closer together on the dorsum than on the venter and sides; this more closely spaced condition of the dorsal sulci is in part the result of intercalation of additional sulci just below the dorsolateral shoulder.

On the largest specimen available for study the aperture is neither constricted nor flaring. There is no evidence that any of the available specimens are fully mature or gerontic individuals, and hence interpretations concerning the nature of the aperture are rather uncertain.

The septal spacing, varying from 2.5 to 5 mm. apart, is equal on the average to about one-eighth of the dorsoventral diameter. Although none of the septa are complete, they appear to have been moderately convex apicad. The sutures are visible on an exfoliated specimen and are approximately transverse to the conch although slightly sinuous, forming a broad, shallow saddle across the venter, a smaller but similar lobe on and above the ventrolateral shoulder, a similar saddle on and below the dorsolateral shoulder, and a nearly straight line across the dorsal surface. It is uncertain whether the suture pattern was distorted during fossilization or whether the present pattern is the true one. The position and nature of the siphuncle are unknown.

Remarks.—These specimens appear to be rather closely related to the species of *Poterioceras* described by Meek and Worthen as *Cyrtoceras curtum*, whose type specimen has been available for study through the

courtesy of Dr. A. H. Sutton, formerly of the University of Illinois. The type specimen of *P. curtum* is smaller than any of the Ohio specimens, but it may be a more immature individual. Moreover, the convergence of the flanks and the increase in lateral diameter is greater than in any of the specimens at hand, but some of the difference appears to be due to distortion of the Illinois specimen. The surface sculpture is similar on both the Illinois and Ohio specimens, and the suture patterns do not appear to be unlike, although difference in size and possible distortion makes comparison of the sutures unreliable.

It seems probable that the Ohio specimens are not conspecific with *P. curtum*, but their poor state of preservation makes a definite conclusion impossible. It is not entirely certain that they represent a single species, for the specimens from the Hamden are larger and more quadrangular in cross section of the conch. Because of these uncertainties specific identification is deferred until better material is available.

Occurrence.—Three specimens were collected from the Vanport member in the now abandoned mine on the N. Weingart farm, east-central part, section 7, Green Township, Mahoning County. One of the Hamden limestone specimens is from the now abandoned H. L. Dougherty mine, northeast corner, section 19, Green Township, Mahoning County, and the others are from the same member in the Salem Coal Company's mine, southwester quarter, section 33, Green Township, Mahoning County.

Repository.—Geological Museum, Ohio State University, Columbus, Ohio. no. 18703.

Genus EPHIPPIOCERAS Hyatt

EPHIPPIOCERAS FERRATUM (Cox)

Plate 4, figures 2–4

1857. *Nautilus ferratus* Cox, Kentucky Geol. Survey Rept., vol. 3, pp. 574–575, pl. 10, figs. 2, 2a.
Pennsylvanian: Edmonson County, Kentucky.

1883. *Ephippioceras ferratum* Hyatt, Boston Soc. Nat. History Proc., vol. 22, p. 290.

1933. *Ephippioceras ferratum* Miller, Dunbar, and Condra, Nebraska Geol. Survey, ser. 2, Bull. 9, pp. 114–118, pl. 3, figs. 14–17.
Pennsylvanian: Widespread.

This is another species that is well known. Its more important features are summarized as follows:

Conch of moderate size, subglobose, nautiliconic, consisting of about three rapidly expanding whorls at maturity. The early whorls, which cannot be observed on the specimens at hand, are reported to be subcircular to subelliptical in cross section; mature whorl section reniform, being broadly rounded from center of venter to umbilical shoulder, narrowly rounded or subangular across umbilical shoulder, slightly convex across dorsolateral surface, and impressed dorsally. The two largest specimens examined have a conch diameter of about 50 mm. and a maximum transverse whorl diameter of almost 50 mm., and a height of about 20 mm. from the impressed zone to the venter. The impressed dorsal zone is at least 8 mm. deep. The umbilicus is small, steep-walled, and deep and has a tiny lance-shaped perforation about 1 mm. long and one-third mm. wide. Inner volutions are reported to be concealed; the living chamber occupies one-third of a volution.

Test moderately thin and ornamented by numerous fine transverse growth lines, which are slightly convex orad on the flanks and form a wide, rounded, and moderately deep sinus on the ventral side. A midventral raised line is present on the mold of the interior.

Septa rather closely spaced; sutures approximately transverse to the long axis of the conch, somewhat sinuous. The sutures form a broad and subacute ventral saddle bordered on each side by a broad and very shallow lateral lobe, a small rounded saddle at the umbilical shoulder, a rounded and very shallow dorsolateral lobe, a small angular saddle at the umbilical seam, and two rounded dorsal lobes flanking a median rounded dorsal saddle. The septa are rather concave orad and have a median dorsoventral fold connecting the ventral and dorsal saddles.

Siphuncle small, central or nearly so, orthochoanitic in structure, with short straight septal necks and cylindrical connecting rings.

Remarks.—Four specimens of this common species were available for study. The dimensions of the two largest specimens are given above in the description of the species.

One of these is nearly complete but is partly concealed by the matrix; the other consists of about one-half of the outer whorl and shows clearly the impressed zone, one septum, and the size and position of the siphuncle. On this latter specimen the ventral saddle is shorter and blunter than the corresponding saddle on the two smaller exfoliated specimens of the collection. Possibly this large specimen is a representative of the inadequately known species *Ephippioceras divisum* (White and St. John). The surface ornamentation of the test is fairly well preserved on the nearly complete large specimen, and the fine growth lirae are visible. At more or less regular intervals certain of the growth lines are more prominent than the others, and this variation is especially noticeable near the umbilical shoulder. The midventral raised line and the sutures are visible on the immature exfoliated specimens, one of which was sectioned to show the structure and position of the siphuncle and the minute umbilical perforation.

Occurrence.—All the specimens identified as representatives of this species are from the Hamden limestone. Three specimens were collected from shale piles at the now abandoned H. L. Dougherty mine just west of New Albany in the northeast corner of section 19, Green Township, Mahoning County, and the other one was found on the shale pile at the now abandoned Ed. Shepherd mine, northcentral part of section 33, Green Township, Mahoning County. There is an additional unfigured specimen doubtfully referred to this species from the Hamden member at an abandoned mine, section 15, Salem Township, Columbiana County.

Repository.—Geological Museum, Ohio State University, Columbus, Ohio, nos. 18708 and 18709.

Genus LIROCERAS Teichert

LIROCERAS LIRATUM (Girty)
Plate 4, figures 6–9

1911. *Coloceras liratum* Girty, New York Acad. Sci. Annals, vol. 21, p. 144.
Wewoka formation: Wewoka and Coalgate quadrangles, Oklahoma.
1915. *Coloceras liratum* Girty, U. S. Geol. Survey Bull. 544, pp. 237–238, pl. 28, figs. 2–6a.
Wewoka formation: Wewoka and Coalgate quadrangles, Oklahoma.
1933. *Coloceras liratum* Miller, Dunbar, and Condra, Nebraska Geol. Survey, ser. 2, Bull. 9, pp. 132–134, pl. 6, figs. 1–8.
Pennsylvanian: Mid-Continent area and Texas.
1940. *Liroceras liratum* Teichert, Jour. Paleontology, vol. 14, p. 590.
Pennsylvanian and Lower Permian: (Genus) World-wide.

The description given below is in part from the publications listed in the synonomy and in part from observations on the specimens at hand.

Conch small, subglobose, nautiliconic, rapidly expanding. Two fragmentary specimens have an estimated diameter of 25 to 30 mm. measured from the adoral end across the umbilicus to the opposite side of the conch. The mature whorl has a depressed, reniform section, being rounded ventrally and laterally except for a median ventral flattening, slightly convex on the dorsolateral wall, and impressed dorsally. The umbilical shoulder is obtusely rounded; the shoulder at the umbilical seam is narrowly rounded to subangular. The greatest width of the whorl is between the umbilical shoulders. The largest fragmentary specimen has the following whorl measurements taken near each end of the specimen:

	Apicad end	Adoral end
Width between dorsolateral shoulders	17.0 mm.	24.0 mm.
Height (from depressed zone)	8.5 mm.	12.0 mm.
Height (maximum)	10.7 mm.	14.0 mm.
Width of umbilical wall (average)	6.0 mm.	
Width of impressed zone (average)	8.0 mm.	
Depth of impressed zone (average)	2.0 mm.	

This specimen has a length of about 30 mm. measured along the median line of the venter, but the measurement along the umbili-

cal shoulder is only about one-third as much.

The umbilicus is small, deep, and perforate. A sectioned and polished specimen, doubtfully referred to this species, has a comma-shaped perforation, the head of which has a diameter of about 2.0 mm. The apicad portion of the conch expands very rapidly in diameter, and the whorls are not in contact until the conch has attained one and one quarter volutions.

The thin test is marked by fine incremental lirae, and in addition on the umbilical wall and the adjacent flank of the whorl by fine revolving lirae that are separated by wide interspaces. On the venter the growth lines are described by Girty as follows:

> The ventral surface is crossed by fine, incremental striae, which indicate a deep subangular V-shaped sinus, whose sides are nearly straight over the median portion but curve gracefully outward with increasing rapidity toward the sides. In one (some) specimen the striae are so arranged that every seventh or eighth is stronger than the others which cross the slightly elevated spaces between in crowded though regular order.

The septa are reported by Girty to be about 6 mm. apart along the median ventral line of mature whorls, but on an immature specimen studied the septa are only 2 mm. apart where the conch has a maximum width of 7 mm. The sectioned specimen mentioned above and doubtfully referred to this species has a maximum spacing of septa slightly less than 3 mm. This specimen appears to be mature as the adoral septa are more closely spaced than those further apicad, although the conch's diameter measured from the adoral end across the umbilicus to the opposite side is only about 27 mm. The septa are moderately convex apicad, with the greatest convexity dorsad of the center of the conch. The sutures of the older portions of the conch are only faintly sinuous and nearly transverse to the axis of the conch. On the large specimens the sutures form a broad, very shallow, ventral lobe, a nearly straight line across the flanks and the umbilical shoulders, a faint dorsolateral lobe, a small pointed saddle at the umbilical seam, and a rounded dorsal lobe. The mold of the interior also bears a raised, median, ventral line.

The siphuncle is small, orthochoanitic, and between the center and dorsal side of the conch. The septal necks and connecting rings are almost straight, the siphuncular segments being very slightly expanded within the camerae.

Remarks.—Specimens from the Allegheny series of eastern Ohio differ in no important respect from the descriptions of specimens from other regions, unless it be in the spacing of the septa. The reticulate surface markings on the umbilical and lateral walls are unique among the species of this genus. *Liroceras obsoletum* (Girty) can be distinguished from *L. liratum* by the absence of the reticulate markings and by the nearly central position of the siphuncle. *L. greeni* (Miller, Dunbar, and Condra) is larger and has a wider umbilicus than *L. liratum* and also lacks the reticulate surface markings. *L. milleri* (Newell) is a very large species with a plugged umbilicus. *L. missouriense* (Swallow) is too poorly known for comparison.

Occurrence.—The figured specimens are from the Hamden limestone of the Lisbon quadrangle. The exact locality of one is unknown. One came from the now abandoned H. L. Dougherty mine, northeast corner, section 19, Green Township, Mahoning County. The other one came from the now abandoned Ed. Shepherd mine, north-central part, section 33, Green Township, Mahoning County.

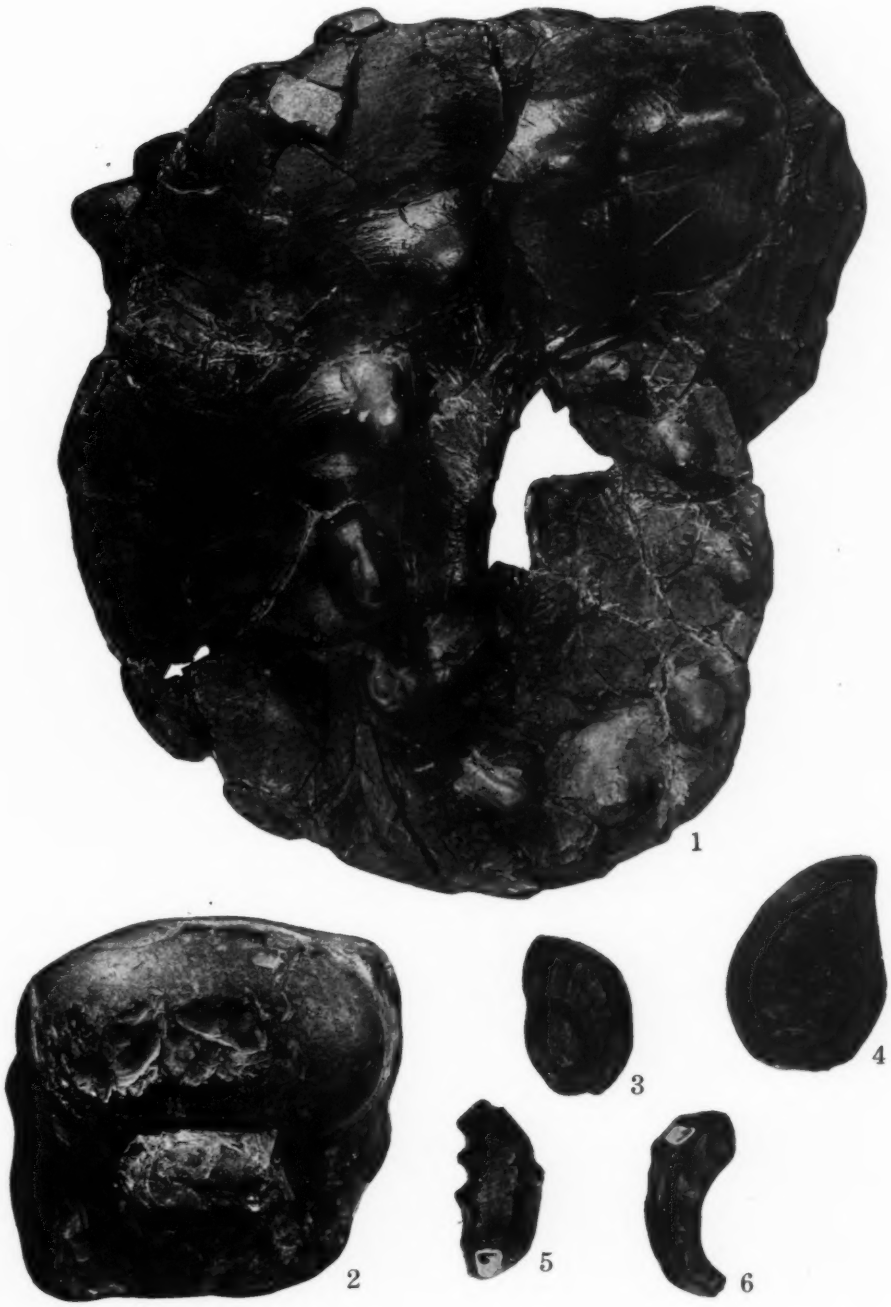
Repository.—Geological Museum, Ohio

EXPLANATION OF PLATE 5

FIGS. *1, 2—Temnocheilus medioventralis* Sturgeon, n. sp. *1*, Lateral view of crushed cotype, ×1. *2*, Septal (apical) view of two whorls of the other cotype, ×1. Both specimens are from the Hamden limestone at adjacent localities, section 33, Green Township, Mahoning County, Ohio. (p. 22)

3, 4—Metacoceras tricarinatum parvinodosum Sturgeon, n. var. Lateral views of two of the cotypes, ×1½, from the Vanport limestone, section 7, Green Township, Mahoning County, Ohio. (p. 25)

5, 6—Metacoceras tricarinatum Sturgeon, n. sp. Ventral and lateral views of the two cotypes, ×1½, from the Vanport limestone, section 7, Green Township, Mahoning County, Ohio. (p. 24)



Sturgeon, Pennsylvanian Nautiloidea

Sturgeon, Pennsylvanian Nautiloidea

State University, Columbus, Ohio, nos. 18710, 18711, and 18712.

Genus TEMNOCHEILUS McCoy

TEMNOCHEILUS QUINQUELIRATUS Sturgeon, n. sp.

Plate 6, figures 1, 2

The holotype, which is the only known specimen of this species, is an exfoliated and fragmentary portion of a single whorl of the phragmacone. It has a length of 70 mm. measured along the median line of the venter, a width of about 35 mm. between the base of the whorls near the adoral end, and a width, also measured between the bases of the nodes, of about 27 mm. near the adapical end. The width including the nodes is at least 5 mm. greater. The indicated diameter of the conch is more than 55 mm.

The conch is small to medium-sized, tarphyceraconic, gradually and regularly increasing in size throughout the preserved portion. The whorl cross section is strongly depressed dorsoventrally, subelliptical in outline; being very broadly rounded ventrally, narrowly rounded laterally and dorsolaterally, and probably slightly impressed dorsally. The nature of the early whorls, the living chamber, and the aperture cannot be determined from the type specimen.

The test is exfoliated, and hence its thickness and external markings are unknown. The interior mold bears a faint, broad, median, longitudinal lira on the ventral side and two parallel lirae of similar size, which are separated by a relatively narrow groove on the ventrolateral shoulders. There is also a single row of large, prominent, pointed, conical nodes on each of these shoulders. The ventrolateral lirae pass up and over the nodes, which are slightly elongate and confluent because of the double-crested ridge formed by the lirae. The nodes, which are spaced 15 to 16 mm. apart, are about 4 mm. in height but were undoubtedly much higher on the exterior of the conch and probably numbered 10 to 12 pairs to the whorl. They extend laterally with only a slight ventral obliquity and thus form a shallow concave zone between their crests and the crown of the venter. The nodes of one shoulder are not directly opposite those on the opposite shoulder.

The septa are moderately far apart, and their spacing indicates an immature individual. The ratio of the length of the camerae to the width of the whorl between the bases of the nodes is almost 1:4.5. The sutures are transverse and slightly sinuous, forming a very broad, shallow, and rounded lobe across the venter and a faint, rounded saddle at the umbilical shoulder. They are straight across the flanks and dorsolateral sides and are unknown on the dorsum. The ventrolateral saddle is more pronounced on sutures that cross the nodes. The position and nature of the siphuncle are unknown.

Remarks.—In spite of its very fragmen-

EXPLANATION OF PLATE 6

FIGS. *1, 2—Temnocheilus quinqueliratus* Sturgeon, n. sp. Lateral and ventral views of the holotype, ×1, from the Vanport limestone, Bolivar, Ohio. (p. 21)

3, 4—Metacoceras perelegans Girty. *3*, Lateral view of a specimen, ×1, from the Hamden limestone, section 33, Green Township, Mahoning County, Ohio, *4*, Ventral view of a fragmentary specimen, approximately ×2, from the Hamden limestone at an unknown locality within the Lisbon (Ohio) quadrangle. (p. 25)

5—Parametacoceras? sp. Lateral view of a fragmentary specimen, ×1½, from the Vanport limestone, section 7, Green Township, Mahoning County, Ohio. (p. 28)

6, 7—Metacoceras sp. 1. *6*, Lateral view of a fragmentary specimen, ×1, from the Hamden limestone, section 29, Perry Township, Columbiana County, Ohio. *7*, Ventrolateral view of a fragmentary specimen, ×1, from the Hamden limestone, section 33, Green Township, Mahoning County, Ohio. (p. 27)

8—Temnocheilus medioventralis Sturgeon, n. sp. Ventral view of one of the cotypes, ×1, from the Hamden limestone, section 33, Green Township, Mahoning County, Ohio. (p. 22)

9–11—Metacoceras lambi Sturgeon, n. sp. Cross, ventral, and lateral views of the holotype, ×1, from the Hamden limestone, section 33, Green Township, Mahoning County, Ohio. (p. 26)

12–15—Metacoceras sp. 2. *12, 13*, Lateral and ventral views of the only known specimen, ×1. *14*, Ventrolateral view of part of the same specimen, slightly more than ×1. *15*, View of apical end of the same specimen, slightly less than ×2. From the Hamden limestone, section 14, Salem Township, Columbiana County, Ohio. (p. 27)

tary and immature condition the specimen can be distinguished from all the described species of the genus *Temnocheilus*. Its distinctive features are the large and widely spaced nodes, the five longitudinal lirae on the internal mold, and possibly its small size. There is the possibility that if the external features of this specimen were known it might be conspecific with some described species; but until its relationship to some known species can be demonstrated, it is best to consider this specimen as a distinct species.

Occurrence.—E. J. Bognar collected this specimen from the Vanport limestone in the pit of the Bolivar Clay Product Company, Bolivar, Ohio.

Repository.—Geological Museum, Ohio State University, Columbus, Ohio, no. 18713.

TEMNOCHEILUS MEDIOVENTRALIS Sturgeon, n. sp.

Plate 5, figures 1, 2; plate 6, figure 8

Numerous fragments of individuals representing the genus *Temnocheilus* have been collected from the Hamden member of the Lisbon quadrangle. In fact, if the number of preserved fragments is a safe criterion, representatives of the genus *Temnocheilus* must have been the most abundant group of nautiloid cephalopods in the Hamden sea of the Lisbon district. These fragments may include several species, but many specimens are so insufficiently or poorly preserved that positive specific identification is impossible. Some individuals have preserved only a portion of the shell bearing a few nodes; other specimens are badly crushed or embedded in firm limestone from which they cannot be extracted satisfactorily. It seems possible on the basis of the material collected to date to recognize at least two species. These are described as fully as the fragmentary condition of the material permits.

The first species is represented by two partially preserved specimens, many shell fragments, and individual nodes. One badly crushed specimen consists of about three whorls, and the second has preserved about one-fourth of two whorls of the phragmacone. The crushed specimen must have had an original diameter, measured from the adoral end of the venter across the umbilicus to the opposite side of the specimen, of at least 110 mm. The outer whorl of the second specimen has a transverse diameter of 50 mm., a dorsoventral diameter of about 30 mm., and a dorsal impressed zone about 20 mm. wide and only about 2 mm. deep. The inner whorl of the same specimen is about 17 mm. wide and 14 mm. high. The whorl dimensions cannot be determined on the badly crushed specimen. In addition there is a third doubtful specimen that consists of one-half of a large outer whorl, on which the nodes are more or less confluent. This specimen has a width of about 70 mm. across the venter to the outside of the nodes.

The conch is large, tarphyceraconic, moderately and gradually increasing in size, with a wide and deep umbilicus. The length of body chamber and the features of the aperture are unknown, except that the growth lines indicate a broad and rather deep hyponomic sinus. The whorl section is dorsoventrally depressed and is irregularly hexagonal to subrectangular in cross section, being broadly rounded ventrally, more narrowly rounded laterally, somewhat flattened dorsolaterally, and slightly impressed dorsally. On the slightly convex venter there is a median flattened zone, from which the surface slopes gently to the ventrolateral zone. The dorsolateral shoulders are somewhat more widely rounded than the ventrolateral ones, and the angulation at the umbilical seam is obtuse.

The test of the several specimens varies in thickness from less than 1 mm. on the ventral, lateral, and dorsolateral surfaces to 1.5 mm. on the ventrolateral shoulder and a much greater thickness in the nodes themselves. The surface markings consist of fine growth lines, which are essentially straight or slightly concave orad on the dorsolateral and lateral surfaces; dorsad of the ventrolateral shoulder they swing sharply apicad and form a broad, deep, tongue-shaped sinus as they cross the venter. Faint longitudinal lirae are present on the ventral surface of the crushed specimen. The conspicuous external features of the conch are the large, rounded, nonconfluent nodes that form a single row on each of the ventrolateral zones. The nodes, which in one row are not directly opposite those in the other row, are blunt, more or less oval in cross section,

and seem to have projected both laterally and ventrally.

There is a tendency for the orad nodes on the crushed specimen to become elongate in the direction of the long axis of the whorl and even to become somewhat confluent. The outer whorl of the same specimen has 12 to 14 nodes, as near as can be estimated from the present condition of the specimen, and these nodes attain a maximum height of about 10 mm. and a maximum diameter of 15 mm. or more. The nodes are much less noticeable on the interior molds of the specimens than they are on the conch's exterior.

The septa are moderately convex apicad and closely spaced, nine camerae occurring in a distance of 40 mm. measured along the median line of the venter. The nearly transverse and slightly sinuous sutures form a broad, shallow, median saddle bordered by similar lobes on the venter; a ventrolateral saddle; a broad, shallow, lateral lobe; a rounded saddle at the umbilical shoulder; a broad, shallow, dorsolateral lobe; a subangular saddle at the umbilical seam; and a broad, rounded, dorsal lobe.

On the next inner whorl of the same specimen the sutures are not well preserved, but on the venter there is no median saddle, there being a single broad lobe across the venter. The siphuncle is centrally located and is presumably orthochoanitic in structure as in other species of the genus. The cross section of the siphuncle exposed within a camera is slightly elliptical, measuring 6.5 mm. in height and 5 mm. in width where the conch has a height of 30 mm. and a width of 50 mm.

Remarks.—While these specimens have some features in common with several of the described species of *Temnocheilus* from the Pennsylvanian system of North America, it is doubtful whether they are conspecific with any of the known species. The whorl section is similar to that of *Temnocheilus subrectangularis* Miller, Dunbar, and Condra from the Kendrick shale of Kentucky, but the Ohio specimens differ notably in having fewer large nodes, which are conical instead of confluent, and in the possession of a median ventral saddle. *T. johnsoni* Miller, Dunbar, and Condra from the Pennsylvanian of the Sangre de Cristo region of Colorado has elongate nodes, a broad, slightly concave zone along the median part of the venter, more numerous nodes, and no midventral saddle. The nodes of *T. harneri* Miller and Owen from the Cherokee formation of Missouri are very similar, but the whorl cross sections are apparently more elliptical. *T. latus* (Meek and Worthen) and *T. winslowi* (Meek and Worthen) from the Pennsylvanian of Illinois can be distinguished by more or less elliptical whorl sections and confluent nodes. *T. quinqueliratus*, n. sp., is smaller, has very strong nodes, an elliptical whorl cross section, and a longitudinally lirate internal mold.

It is doubtful whether the specimen in the collection with the more or less confluent nodes is conspecific with the other specimens. Its affinities may be with *T. latus* and *T. winslowi*, but because of the poor preservation a definite conclusion cannot be reached.

While the two specimens described here are fragmentary, they supplement each other so well that many of the specific features are known. It is believed that they represent the same species, and since they seem to be conspecific with no other described species, they are designated as cotypes, and the specific name of *T. medioventralis* is proposed in reference to the midventral saddle.

Occurrence.—As mentioned above, incomplete specimens of this species of *Temnocheilus* are abundant in the Hamden limestone in the Lisbon quadrangle. One of the two figured specimens is from the abandoned Ed. Shepherd mine, north-central part, section 33, Green Township, Mahoning County, and the other specimen is from the Salem Coal Company's mine in the southwest quarter of the same section and township.

Repository.—Geological Museum, Ohio State University, Columbus, Ohio, nos. 18714 and 18715.

TEMNOCHEILUS sp.
Plate 4, figure 5

The conch is medium-sized to large, tarphyceraconic, increasing in size apparently with only moderate rapidity. The only specimen collected is a fragment of a single whorl about 45 mm. long, measured along the median line of the venter. The whorl is

48 mm. wide across the venter to the inside of the nodes and is about 25 mm. high. The whorl cross section is broadly rounded ventrally, narrowly rounded ventrolaterally, broadly rounded laterally and dorsolaterally, and slightly impressed dorsally. The dorsolateral surfaces merge gradually into the lateral sides, so that the whorl cross section is subelliptical. The nature of the body whorl is unknown, and the umbilicus is presumably wide and deep.

The surface features and the nodes are poorly preserved. The nodes appear to have been medium-sized, bluntly rounded, and not confluent. They are easily discernible on the internal mold.

Six septa (5 camerae) occur in a distance of 45 mm. along the median line of the venter. The sutures are nearly transverse and slightly sinuous. They consist of a broad, shallow ventral lobe, a sharply rounded ventrolateral saddle, a very slight and broad saddle on the lateral and dorsolateral sides, a subangular saddle at the umbilical seam, and a dorsal lobe. The siphuncle is central and has a diameter of about 4 mm. at its passage through a septum.

Remarks.—This specimen may belong to *Temnocheilus medioventralis*, n. sp., described above but it seems to differ from that species in having a more elliptical cross section of the whorl, a wider spacing of the septa, and a single broad ventral lobe instead of a median ventral saddle flanked by two lobes on the venter. As far as can be learned it seems to be more closely related to *T. harneri* Miller and Owen than to *T. medioventralis*, n. sp.

Occurrence.—From the Hamden limestone of the Lisbon quadrangle, exact locality unknown.

Repository.—Geological Museum, Ohio State University, Columbus, Ohio, no. 18716.

Genus METACOCERAS Hyatt
METACOCERAS TRICARINATUM
Sturgeon, n. sp.
Plate 5, figures 5, 6

The material representing this species includes two fragmentary and partially crushed specimens. It is impossible to determine much in the way of exact measurements or to make observations of many important features, but certain discernible features distinguish them from all other North American Pennsylvanian described species.

The conch is small, tarphyceraconic, presumably moderately and regularly expanding and subdiscoidal. The whorls are much depressed and irregularly hexagonal to subquadrate in cross section. The venter is broad and moderately convex; the lateral sides are flat and narrow with slight convergence dorsad; the dorsolateral surfaces are also flattened; and the dorsum is probably slightly impressed. The umbilicus is not preserved but appears to have been moderately large, deep, and steep-walled. The ventrolateral shoulder is subangular, and the umbilical shoulder is angular and raised into a carina. Each ventrolateral shoulder bears a row of large and bluntly rounded nodes that extend laterally and slightly upward. The bases of the tubercles extend dorsally almost across the lateral sides as rather definite plications. In addition to the carina on the umbilical shoulder there are two more carinae on the ventrolateral shoulder. The stronger of these marks the rather sharp change in slope from the venter to the sides. This is not a straight carina but is scalloped between the bases of the nodes with moderate concavity outward from the venter. There is a less-definite carina that passes through the apices of the tubercles and is better developed on the nodes than on the intervening spaces. The transverse growth lirae are inconspicuous and attain their maximum strength between the two ventrolateral lirae. The growth lirae are almost transverse on the flanks, swing slightly orad between the ventrolateral carinae, and form a deep and broad sinus on the ventral surface. The shell is moderately thin and slightly thickened under the carinae so that they are not reflected on the internal mold. The internal features of the conch are unknown.

Remarks.—These specimens represent a heretofore undescribed species of *Metacoceras* that is closely related to *M. carinatum* Girty from the Wewoka formation of Oklahoma, from which they differ in having the two ventrolateral carinae in addition to the carina on the umbilical shoulder.

Occurrence.—Both specimens came from the Vanport limestone in the abandoned

mine on the N. Weingart farm, east-central part, section 7, Green Township, Mahoning County.

Repository.—Geological Museum, Ohio State University, Columbus, Ohio, no. 18717.

METACOCERAS TRICARINATUM PARVINODOSUM Sturgeon, n. var.
Plate 5, figures 3, 4

In addition to the two specimens described as *Metacoceras tricarinatum*, there are four specimens from the same locality that are similar except that they have much smaller, more numerous, and more closely spaced ventrolateral nodes. It is entirely possible that all six are conspecific but it cannot be proved at present from the specimens at hand. Similarity in size indicates that those having small nodes are not young individuals that would have large nodes in later stages of growth. Since the two forms are readily distinguishable from each other, those with the small nodes are here considered to be a separate variety.

Occurrence.—From the Vanport member in the abandoned mine on the N. Weingart farm, east-central part, section 7, Green Township, Mahoning County.

Repository.—Geological Museum, Ohio State University, Columbus, Ohio, no. 18718.

METACOCERAS PERELEGANS Girty
Plate 6, figures 3, 4

1911. *Metacoceras perelegans* Girty, New York Acad. Sci. Annals, vol. 21, p. 147.
Wewoka formation: Wewoka and Coalgate quadrangles, Oklahoma.
1915. *Metacoceras perelegans* Girty, U. S. Geol. Survey Bull. 544, pp. 244–245, pl. 30, figs. 5, 6.
Wewoka formation: Wewoka and Coalgate quadrangles, Oklahoma.

Several specimens are assigned to this species. One supposedly adult specimen is fairly complete, but the others consist of only portions of single whorls. The conch of the nearly complete specimen has a maximum diameter of 36 mm. measured from the adoral end of the venter across the umbilicus to the opposite side and a diameter of 32 mm. measured at right angles to the maximum diameter. The outer whorl is 17 mm. in maximum width and more than 12 mm. high. Since Girty has adequately described this species, only a summary is given here.

Conch small, tarphyceraconic, gradually and regularly expanding. The whorl cross section is depressed dorsoventrally and irregularly hexagonal in outline, being convex with a median flattened zone on the venter, nearly flat except for nodes and plications on the flanks, nearly flat or slightly concave on the dorsolateral surface, and slightly impressed on the dorsal surface. Convergence of the sides is slightly ventrad; ventrolateral and umbilical shoulders are angular to subangular. The umbilicus is steep-walled and moderately large; its diameter is about one-half of the diameter of the conch.

The surface markings consist of transverse lirae separated by somewhat broader striae. The transverse markings are slightly deflected apicad on the dorsolateral faces, nearly straight on the flanks, and sweep far apicad on the venter to form a deep and broad sinus. On the lateral sides of the whorl there are transverse plications that terminate in rounded nodes at the ventrolateral and umbilical shoulders and tend to become less strongly developed orad, and finally to disappear. The ventrolateral nodes are considerably stronger than those on the umbilical shoulder and are strongly marked on the internal mold, while the umbilical nodes are not discernible on the internal mold.

The internal mold shows also a raised median line along the center of the venter, and in youthful stages the transverse lateral plications. The sutures, which are about 3 mm. apart on the venter, are slightly sinuous and form definite ventral and lateral lobes separated by less pronounced ventrolateral saddles, an additional saddle at the umbilical seam, a nearly straight line on the dorsolateral zone, a saddle at the umbilical seam, and a pointed dorsal lobe. The siphuncle is slightly ventrad to the center, and presumably orthochoanitic in structure, as the septal necks are short and straight.

Remarks.—These specimens appear to be conspecific with those described by Girty as *Metacoceras perelegans* from the Wewoka formation of Oklahoma. Shortly before his death Dr. Girty examined the Ohio speci-

mens and kindly loaned his type specimens for study. While there are some minor differences between the Wewoka and Ohio specimens, there is also an equal amount of variation among the Ohio specimens.

Occurrence.—All specimens are from the Hamden limestone at the following localities: abandoned H. L. Dougherty mine, northeast corner, section 19, Green Township, Mahoning County; Brookwood mine, west-central part, section 29, Perry Township, Columbiana County; abandoned Ed. Shepherd mine, north-central part, section 33, Green Township, Mahoning County; abandoned McKeefrey mine, north-central part, section 15, Salem Township, Columbiana County.

Repository.—Geological Museum, Ohio State University, Columbus, Ohio, nos. 18719 and 18720.

METACOCERAS LAMBI Sturgeon, n. sp.
Plate 6, figures 9–11

The only known specimen of this species is the holotype, which consists of about one-fourth of a test-covered whorl that is incomplete at each end. From this fragment it is apparent that the conch was moderate in size, tarphyceraconic in manner of growth, and subdiscoidal in form. The whorl is much depressed dorsoventrally, and as a result the whorl's irregular hexagonal cross section is strongly transverse. The broad flattened venter is slightly convex, and in fact it is really biconvex as there is a prominent longitudinal groove running along its median line. The flattened lateral sides, whose convergence is toward the venter, are convex, and the umbilical walls are convex on both the exterior of the test and on the internal mold. A slight impressed zone marks the impression of the previous whorl on the dorsal surface. On the exterior the ventrolateral and umbilical shoulders are abrupt and angular, the angle in each being more than a right angle. In cross section these same angulations are less abrupt because of the thickening of the test on these shoulders. The angle at the umbilical seam is likewise obtuse. The umbilicus appears to have been rather small but steep-walled and deep. The following whorl measurements were taken near the orad end of the specimen:

Width between ventrolateral shoulders	19.6 mm.
Maximum width through nodes, about	21.0 mm.
Width between umbilical shoulders, about	23.0 mm.
Maximum height	14.0 mm.
Width of lateral side	10.0 mm.
Width of umbilical wall	8.6 mm.

The average thickness of the test is determined to be about 0.3 mm., but at the ventrolateral and umbilical shoulders the thickness is as much as 1 mm. Both the ventrolateral and umbilical shoulders are ornamented by a row of nodes, and the nodes on the ventrolateral shoulders are considerably larger than those on the umbilical shoulders. In almost every case there is a complete plication or ridge connecting each node of the ventrolateral shoulder with the corresponding node on the umbilical shoulder. Some of the plications are discontinuous; the others are slightly concave orad. The nodes of the ventrolateral shoulder, which are between 5 and 6 mm. apart, are obliquely elongate in the same direction as the axis of the whorl. Furthermore they extend outward and downward, forming a longitudinal concavity between the crests of the nodes and the convexity on each side of the median longitudinal sulcus of the venter. On the umbilical shoulder the nodes are about 4 mm. apart, conical or elongated along the connecting plication, and intermediate in height between that of the nodes of the ventrolateral shoulder and that of the connecting plications. The median ventral sulcus lying in a faint and broad concave depression has a width of about 1 mm. and a depth of less than 1 mm. and is broadly rounded and not V-shaped in cross section.

The exterior of the test is ornamented by fine growth lines, which are grouped at intervals into faint, inconspicuous lirae. These growth lines are slightly convex orad on the umbilical wall, nearly straight or oblique apicad on the flanks, deflected sharply apicad just within the ventrolateral nodes on the venter to trace the outline of a broad, rounded, ventral sinus.

Nothing is known concerning the spacing of the septa, and very little can be learned concerning the nature of the septa and the suture pattern. The septa appear to be mod-

erately and evenly convex apicad, and the nearly transverse and sinuous sutures form broad ventral and lateral lobes and a smaller, rounded, ventrolateral saddle. The remainder of the suture pattern and the position and nature of the siphuncle cannot be ascertained but presumably are typical for the genus.

Remarks.—In some respects this specimen seems to be similar to *Metacoceras perelegans* Girty from the Wewoka formation of Oklahoma but differs from that species primarily in having a more transverse whorl section and a prominent longitudinal sulcus along the median line of the venter. This latter feature is the species' most distinctive mark, and the only other species of the genus that has a similar groove is *Metacoceras sulciferum* Miller and Thomas from the Casper formation of Wyoming. The Wyoming species appears to have fewer and more definitely longitudinally oblique nodes, a less pronounced groove along the venter, a less rapidly expanding whorl, and possibly less convex dorsolateral surfaces than the Ohio specimen.

The specific name is given in honor of my first teacher of geology, Professor G. F. Lamb of Mount Union College, Alliance, Ohio.

Occurrence.—This lone specimen is from the Hamden limestone in the Salem Coal Company's mine, southwest quarter section 33, Green Township, Mahoning County.

Repository.—Geological Museum, Ohio State University, Columbus, Ohio, no. 18721.

METACOCERAS sp. 1
Plate 6, figures 6, 7

Several incomplete specimens of the genus *Metacoceras* are difficult to evaluate. These include at least two species different from any of the other species of *Metacoceras* in the collection. The first species or possibly two species is represented by two fragments, each of which shows only the side of a part of a whorl. Each bears a single row of nodes on the ventrolateral and umbilical shoulders without connecting plications between any of the nodes. From such material it is impossible to determine whether the specimens represent the mature stage of *Metacoceras perelegans* Girty on which the plications are entirely obsolete, or whether they are related to the group that have ventrolateral and umbilical nodes without connecting plications at all stages of growth. More and better material will have to be collected before specific identification can be made.

Occurrence.—One specimen is from the Hamden member in the Brookwood mine, west-central part, section 29, Perry Township, Columbiana County, and the other specimen is from the same member in the abandoned Ed. Shepherd mine, north-central part, section 33, Green Township, Mahoning County.

Repository.—Geological Museum, Ohio State University, Columbus, Ohio, nos. 18722 and 18723.

METACOCERAS sp. 2
Plate 6, figures 12–15

Another species of *Metacoceras* is represented by about one-fourth of an almost entirely exfoliated whorl which has at least four camerae of the phragmacone and a portion of the living chamber. Despite the fragmentary condition many features are discernible on this specimen.

This tarphyceraconic conch, when complete, probably had less than three volutions and did not much exceed 35 mm. in diameter. It was evidently the shell of an immature individual, as the spacing of the septa is approximately the same throughout the preserved portion of the phragmacone. The whorl cross section is definitely depressed and irregularly hexagonal in outline, being gently and almost uniformly convex ventrally, flattened laterally, slightly convex on the umbilical wall, and concave dorsally. The median portion of the venter is somewhat flattened, and the flattened flanks, which appear to be almost parallel, do converge ventrad. On the dorsum the impressed zone is 5.5 mm. to 6.5 mm. wide and approximately 1 mm. deep. Some of the whorl measurements at each end of the fragment are:

	Apicad end	Orad end
Width between ventrolateral shoulders	12.5 mm.	15.3 mm.
Maximum width through nodes	14.1 mm.	?

	Apical end	Orad end
Width between umbilical shoulders	14.6 mm.	18.1 mm.
Height from impressed zone	8.7 mm.	11.9 mm.
Width of lateral side	5.3 mm.	8.6 mm.
Width of umbilical wall	4.9 mm.	7.0 mm.

These measurements were taken at a distance of 30 mm. apart measured along the venter. The ventrolateral and umbilical shoulders are abrupt and angular, the angle in each being somewhat greater than 90°. The full size of the living chamber and the nature of the aperture are unknown; the umbilicus was apparently rather small and steep-walled. The almost complete exfoliation of the specimen prevents the determining of much information concerning the thin test, but enough of it is preserved to show the fine, closely spaced, incremental lines and to indicate the presence of a deep, rounded sinus on the venter.

The outline of the sutures, a single faint raised longitudinal line along the venter, and the ventrolateral nodes are visible on the interior mold. In addition a complete septum is exposed on the apicad end. The median ventral line extends along both the septate portion and the living chamber and is invisible where covered by fragments of the shell. As far as can be discerned the nodes are almost 1 mm. in height and were undoubtedly larger on the exterior of the test. The nodes are about 5 mm. apart, those of one shoulder being offset from those of the opposite shoulder. The septa, which are evenly convex apicad, are about 3 mm. apart, and four septa with the intervening three camerae occupy a space almost 9 mm. in length along the venter. There is enough space in the average width of the whorl for between four and five camerae. The sinuous and nearly transverse septa form a broad, shallow, yet almost angular, ventral lobe; a weak, rounded, ventrolateral saddle; a shallow, rounded, lateral lobe; a very faint saddle on the umbilical shoulder, and an equally faint dorsolateral lobe; a small but pointed saddle at the umbilical seam; and a broad rounded dorsal lobe. The siphuncle, which has a diameter of about 1 mm., at its passage through a septum, is located slightly ventrad from the center and is presumably orthochoanitic in structure.

Remarks.—While the features of this specimen do not seem to fit those of any described species, it is too immature and fragmentary to deserve a specific name. In some respects it seems to be related to *Metacoceras cornutum* Girty from the Wewoka formation of Oklahoma, especially in regard to the transverse character of the whorl cross section, the ratio of septal spacing, and other features. The differences, however, are many, some of which might be accounted for by the more immature condition of the Ohio specimen. It is much smaller than the Oklahoma species and more transverse in whorl section, has relatively wider dorsolateral or umbilical surfaces, a raised median, ventral line on the internal mold and an eccentric siphuncle. There are also differences in the suture pattern; and when all is considered, it is evident that they are not conspecific. *M. carinatum* Girty, also from the Wewoka formation of Oklahoma, has a whorl cross section even more like that of the Ohio specimen than *M. cornutum*, but *M. carinatum* apparently has a more rapidly expanding whorl, and, of course, it is impossible to compare the umbilical shoulder of these two. *M. lambi*, n. sp., also has a similar whorl section but has nodes on the umbilical shoulder and a prominent sulcus along the median line of the venter.

Occurrence.—From the Hamden member in the now abandoned Delmore mine, southwest quarter, section 14, Salem Township, Columbiana County.

Repository.—Geological Museum, Ohio State University, Columbus, Ohio, no. 18724.

Genus PARAMETACOCERAS Miller and Owen

PARAMETACOCERAS ? sp.
Plate 6, figure 5

Two fragments in the collection may belong to the genus *Parametacoceras*. One con-

EXPLANATION OF PLATE 7

FIGS. *1, 2*—*Domatoceras shepherdi* Sturgeon, n. sp. *1*, Lateral view of the holotype, ×¾. *2*, Lateral view of a crushed paratype. Both specimens from the Hamden limestone, section 33, Green Township, Mahoning County, Ohio. (p. 31)

Sturgeon, Pennsylvanian Nautiloidea

Sturgeon, Pennsylvanian Nautiloidea

sists of about one whorl incomplete at each end, the other of less than one-half a whorl. Both have preserved only one side. The more complete specimen has an approximate diameter of 23 mm., measured from the adoral end of the venter across the umbilicus to the opposite side of the specimen. The coiling of the shell is unusual in that the apicad portion appears to point not inward into the umbilicus but down onto the dorsal side of the living chamber. Such a relationship probably developed accidentally by distortion during preservation.

The conch is small and apparently tarphyceraconic, with the whorl regularly and gradually expanding orad and increasing in dorsoventral diameter from 4 mm. to 10 mm. in a distance of one whorl. The whorl section is subquadrangular to irregularly hexagonal at the largest stages of growth, but rounded at immature stages. The largest preserved stages of the conch are gently convex ventrally, flattened laterally and dorsolaterally, and probably slightly impressed dorsally. The ventrolateral and umbilical shoulders are rather abruptly rounded, the angle on each being slightly greater than a right angle. The umbilicus is small and steep-walled.

The test is about 0.5 mm. thick and is ornamented, except possibly on the umbilical walls, by fine transverse lirae and striae, which appear to rise near the umbilical shoulder, follow a sigmoid path on the flanks, and form a deep sinus on the venter. The sides also have slightly sigmoid transverse obscure plications that follow the path of the growth lines. Lateral, elongate, nodelike plications marked medianly by an extra strong lira are present on the apicad part of the whorl. As the flanks become wide and flat, the plications become more elongate and much more obscure. They tend to be more prominent toward the umbilical shoulder but do not become noded.

The fourth-from-the-last camera orad has a length of 2.4 mm. but the last three camerae are only about half as long. If the closer spacing of the orad septa is a normal condition, it indicates a mature individual. The nearly transverse and slightly sinuous sutures form broad, rounded, ventral and lateral lobes, and narrowly rounded, ventrolateral and dorsolateral saddles. The dorsal suture and the position and nature of the siphuncle are unknown.

Remarks.—If these specimens are valid members of the genus *Parametacoceras*, they are different from any of the described species. *Parametacoceras bellatulum* Miller and Owen is larger than either of the two specimens studied and has faint nodes on the ventrolateral shoulders. *P. schucherti* Miller has fairly well defined ventrolateral nodes, which appear on the internal mold. It is possible that these specimens are immature individuals of some form whose generic affinities could be recognized on more mature specimens, and hence they are placed in the genus *Parametacoceras* only provisionally until more and better specimens can be collected.

Occurrence.—Both specimens are from the Vanport member in the abandoned mine on the N. Weingart farm, east-central part, section 7, Green Township, Mahoning County.

Repository.—Geological Museum, Ohio State University, Columbus, Ohio, no. 18725.

EXPLANATION OF PLATE 8

FIGS. *1–3*—*Domatoceras obsoletum* Sturgeon, n. sp. *1, 2*, Ventral and lateral views of the holotype ×1, from the Hamden limestone, section 33, Green Township, Mahoning County, Ohio. *3*, Polished section of an immature specimen showing siphuncle and septa, ×2, from the Hamden limestone at an unknown locality within the Lisbon (Ohio) quadrangle. (p. 30)

4—*Domatoceras* sp. Lateral view of a fragmentary specimen, ×1, from the Vanport limestone, section 7, Green Township, Mahoning County, Ohio. (p. 32)

5—Nautiloid undetermined. Dorsal and apical view of the only known specimen, ×1, from the Vanport limestone, Bolivar, Ohio. (p. 35)

6—*Solenochilus greenensis* Sturgeon, n. sp. Lateral view of a large and incomplete specimen, a cotype, ×$\frac{3}{4}$, from the Hamden limestone, section 29, Perry Township, Columbiana County, Ohio. (p. 33)

Genus DOMATOCERAS Hyatt

DOMATOCERAS OBSOLETUM Sturgeon, n. sp.

Plate 8, figures 1–3

The conch is tarphyceraconic, moderate in size, regularly and gradually expanding orad, and subdiscoidal in form. The diameter of the largest and most complete specimen, consisting of about two and one-half whorls, measures 70 mm. from the adoral end of the venter across the umbilicus to the opposite side of the conch and about 60 mm. at right angles to the above direction. The umbilicus is moderate in size; its diameter is less than 30 mm. Where the venter is 14.5 mm. wide to the outside of the nodes, the whorl is 18 mm. high, and the lateral side is 16 mm. wide. The greatest width of the whorl is just below the umbilical shoulder.

The moderately compressed outer whorls are irregularly hexagonal in cross section, being flattened or slightly convex ventrally, laterally, and dorsolaterally, and slightly impressed dorsally. The venter is definitely convex, with a median flattened or slightly concave zone occupying the middle third of the surface. The flanks converge somewhat ventrad and are nearly flat except for a rather pronounced convexity near the umbilical shoulder. The umbilical walls are stepped, and the dorsolateral wall of each whorl is steep and slightly sigmoid in outline, with a faint concavity just below the umbilical shoulder and a weak convexity immediately above the umbilical seam. The ventrolateral and umbilical shoulders are abrupt and obtusely angular, the angle at each being not much greater than a right angle. The umbilical shoulder is also raised into a carina, which tends to become less conspicuous on the adoral portion of the conch.

The shell is thin and ornamented by fine transverse lirae and striae that are nearly straight on both the umbilical wall and the dorsal portion of the sides, from which area they swing apicad, at first gently, then more strongly on the ventrolateral shoulders and venter to form a deep rounded reentrant that indicates the presence of a deep and rounded hyponomic sinus in the orad margin of the venter. Stronger lirae and grooves occur at intervals of 2 to 3 mm. on some portions of the test. Very faint longitudinal lirae are present at least on the median zone of the venter. Each ventrolateral shoulder has a single row of numerous, elongate, compressed, and rather inconspicuous nodes. The nodes of each row are almost as numerous as the camerae, and those in one row are offset in respect to those in the other row. Orad the nodes terminate abruptly and are absent on the last 25 mm. of the outer remaining whorl. The abrupt termination of the nodes at such a distance from the aperture suggests that the specimen is mature or approaching maturity, although there is apparently no shortening of the last camerae orad. The shell is very little thickened under the carina of the umbilical angulation and under the ventrolateral shoulder, as the nodes are visible on the internal mold, at least of immature specimens.

About one-third of the outer whorl is nonseptate, and presumably the living chamber occupied at least that much of the whorl. The orad extremity of the conch is destroyed, and hence the outline of the aperture is unknown except as indicated by the growth lirae. Eleven camerae occur in a distance of 65 mm. measured along the venter. The septa are gently and evenly convex apicad. The sutures are incompletely known. They have a broad, rounded, ventral lobe, a ventrolateral saddle, a broad, lateral lobe, a saddle at the umbilical shoulder, and a nearly straight line on the umbilical wall. The siphuncle is small, orthochoanitic in structure, and ventrad with respect to the center of the whorl.

Remarks.—It is believed that these specimens represent an undescribed species of *Domatoceras* that can be recognized by its moderate size, the small involution of its whorls, the subequal dimensions of its whorl's cross section, its carinate umbilical shoulder, and the obsolescence of the nodes on the adoral portion of the mature conch.

Occurrence.—The holotype is from the Hamden limestone in the now abandoned Ed. Shepherd mine, north-central part, section 33, Green Township, Mahoning County. The remaining specimens are from the same member in the Brookwood mine, west-central part, section 29, Perry Township, Columbiana County, and in the Salem Coal Company's mine, southwest quarter, section 33, Green Township, Mahoning County.

Repository.—Geological Museum, Ohio State University, Columbus, Ohio, nos. 18726 and 18727.

DOMATOCERAS SHEPHERDI Sturgeon, n. sp.
Plate 7, figures 1, 2

None of the four specimens available for study is complete orad, and the largest of these, which is septate throughout almost all of the preserved portion, has a maximum diameter of over 140 mm., measured from the adoral end of the venter across the umbilicus to the opposite side. A crushed specimen of about the same size consists of more than three volutions.

The conch is large, tarphyceraconic, subdiscoidal in form, rapidly and regularly expanding. The outer whorl is very high, much compressed, and irregularly hexagonal in cross section, being concave ventrally, flattened laterally, convex dorsolaterally, and impressed dorsally. The umbilicus is only moderately wide, shallow, and perforate, and has stepped walls. Its maximum diameter is about 50 mm., and the diameter at right angles to that measurement is about 35 mm. The umbilical perforation is somewhat elliptical and is about 4 mm. long and 2 mm. wide. The ventrolateral shoulders are abrupt and angular, and each is raised into an irregular, nodose carina. The umbilical shoulder is tumid and broadly rounded, especially on the orad portions of the conch. As a result the flanks are slightly convex near the umbilical shoulders and slightly concave above the ventrolateral shoulders. The whorl has the following dimensions near what appears to be the apicad end of the living chamber:

Height	55 ±	mm.
Maximum width, below umbilical shoulders	40	mm.
Width of venter, to outside of nodes	18	mm.
Width of lateral face	50 ±	mm.
Width of umbilical wall	14	mm.

The maximum height attained by the preserved portion of the whorl is about 60 mm., and the maximum width is almost 50 mm. The above measurements show the considerable amount of ventrad convergence of the whorl's lateral sides.

The first whorl of the conch is rounded and appears to be almost circular in cross section, but the second whorl becomes noticeably compressed as the lateral and umbilical walls become flattened. Later whorls are characterized by a continued increase in height and amount of compression.

The shell is moderately thick and on the average ranges from 1 to 2 mm. in thickness. It is, however, greatly thickened at the umbilical and ventrolateral shoulders and attains a maximum thickness of over 5 mm. at the umbilical shoulder. The increased thickness of the test at both shoulders makes the corresponding shoulders of the interior mold much more rounded than the exterior of the test and greatly lessens the ventral concavity on the interior mold. Each ventrolateral shoulder is marked externally by a strong, ventrad, projecting ridge that is formed by the confluence of a row of compressed and bluntly terminated nodes. The nodes are but faintly marked on the interior mold, which also appears to have several longitudinal lirae along the median third of the venter. These nodes are slightly more numerous than the number of camerae, seven occurring in a distance occupied by six camerae. Additional surface ornamentation consists of fine transverse growth lines, which form a sigmoid pattern on the combined dorsolateral and lateral surfaces and on the venter, where they indicate the presence of a broad, shallow, ventral sinus.

The maximum spacing of the septa is 7 to 8 mm. apart along the flanks and venter and much less in the dorsal part of the conch. The sutures are nearly transverse and somewhat sinuous, and in their course around the outer whorl they form a rounded, ventral lobe, a subangular saddle on the ventrolateral angulation, a broad, rounded, lateral lobe, and a rounded saddle on the umbilical shoulder and dorsolateral wall. The siphuncle is apparently small, orthochoanitic, and located about midway between the center and venter of the conch.

Remarks.—This species is characterized by a very high and compressed mature whorl and a concave venter, in which respects it differs from closely related species. *Domatoceras moorei* Miller, Dunbar, and Condra from the Corbin City limestone of Kansas is somewhat similar but differs further from the specimens at hand by being more involute and consequently in having a smaller umbilicus. *D. williamsi* Miller and Owen from the Cherokee formation of Missouri

has the maximum width of the conch at the umbilical shoulders, nodes on the umbilical shoulders of mature conchs, and less compressed outer whorls. *D. umbilicatum* Hyatt from the Cherokee formation of Kansas is an extremely large species apparently with less compressed outer whorls than the Ohio specimens. *D. highlandense* (Worthen) from the Pennsylvanian of Illinois is similar but too poorly known for comparison.

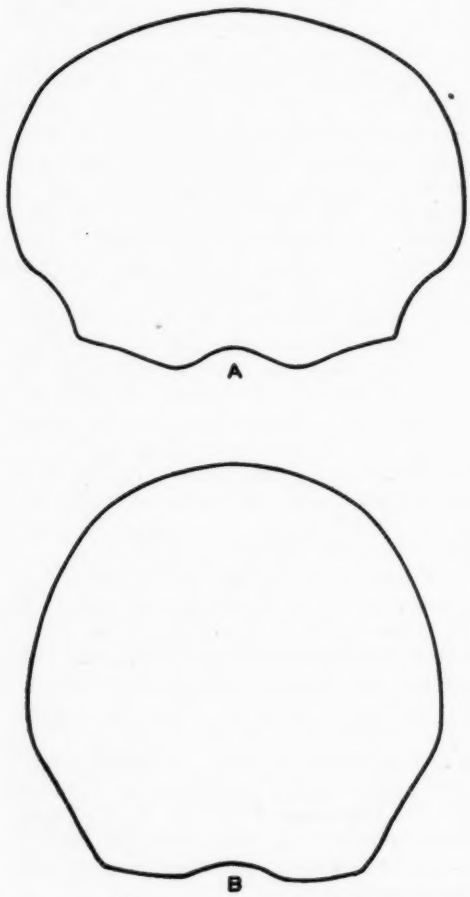


FIG. 3—Diagrammatic cross sections of the conchs of Pennsylvanian nautiloids, ×⅔. *A*, *Solenochilus greenensis* Sturgeon, n. sp. A cotype. *B*, *Solenochilus bognari* Sturgeon, n. sp. The holotype.

The specific name is given in honor of Mr. George Shepherd who collected the holotype.

Occurrence.—The holotype and one of the paratypes are from the Hamden member in the now abandoned Ed. Shepherd mine, north-central part, section 33, Green Township, Mahoning County, and the other paratype is from the Washingtonville shale, southwest quarter, section 36, Green Township, Mahoning County. There is an additional fragment from the Hamden member in the mine of the Salem Coal Company, southwest quarter, section 33, Green Township, Mahoning County.

Repository.—Geological Museum, Ohio State University, Columbus, Ohio, no. 18728. (Only the holotype is numbered at present.)

DOMATOCERAS sp.
Plate 8, figure 4

A fragmentary portion of a single whorl of an immature specimen of *Domatoceras* probably is not conspecific with either of the two species described above. This specimen is too fragmentary and immature for specific identification.

Occurrence.—This specimen was collected from the Vanport limestone at the now abandoned mine on the N. Weingart farm, east-central part, section 7, Green Township, Mahoning County.

Repository.—Geological Museum, Ohio State University, Columbus, Ohio, no. 18729.

Genus SOLENOCHILUS Meek and Worthen
SOLENOCHILUS BOGNARI Sturgeon, n. sp.
Plate 9, figures 1, 2, text figure 3 B

The only known representative of this species is an exfoliated specimen consisting of 12 chambers of the phragmacone and the apicad portion of the living chamber. The specimen is apparently immature, since

EXPLANATION OF PLATE 9

FIGS. *1, 2*—*Solenochilus bognari* Sturgeon, n. sp. Ventral and lateral views of the holotype, ×⅔, from the Vanport, limestone, Bolivar, Ohio. (p. 32)

3—*Solenochilus greenensis* Sturgeon, n. sp. Ventral view of a fragmentary specimen polished to show the structure of the siphuncle, ×1, from the Hamden limestone, section 19, Green Township, Mahoning County, Ohio. (p. 33)

1

2

3

Sturgeon, Pennsylvanian Nautiloidea

there is no crowding of the septa adjacent to the living chamber.

The conch is large, subglobose, and rapidly expanding orad. The maximum diameter of the conch, which is about 150 mm., was undoubtedly considerably greater when the specimen was complete. Near the apicad end of the preserved part of the conch the height and width of the whorl are subequal, being approximately 40 mm.; and near the adoral end the height is about 85 mm. and the width about 95 mm. These measurements were taken 165 mm. apart measured along the median line of the venter. The conch thus tends to become somewhat depressed with growth.

The broadly rounded venter merges across the somewhat broadly rounded and indistinct ventrolateral shoulders with the flattened ventrad three-fifths of the flanks. The inner two-fifths of the flanks are definitely concave, especially near the abruptly subangular and elevated umbilical shoulder. The ventral portion of the flanks converges somewhat toward the venter, and the dorsal portion converges much more strongly toward the dorsum. The two areas of the flanks are separated by a shoulder that is more narrowly rounded than the ventrolateral shoulder. Toward the apicad end of the specimen the flattened ventral portion of the sides becomes more rounded and convex. The greatest width of the whorl is between the shoulders separating the two areas of the flanks, and not between the umbilical shoulders. The umbilical wall is steep, nearly vertical, weakly convex, and merges without a sharp line of separation into the moderately deep impressed dorsal zone. The umbilicus is small, steep-walled, and deep; its diameter is less than 25 mm. where the conch has a diameter of 150 mm.

Except for the sutures and siphuncle, the internal mold appears to be smooth. The septa are far apart, as much as 20 mm. along the median line of the venter but only 5 mm. on the umbilical shoulder. The ratio of the maximum width of the conch to the maximum septal spacing is 4.5:1. The nearly transverse sutures are slightly sinuous and have a small but distinct, low, median, ventral saddle flanked on either side by a similar lobe, a shallow, broad saddle on the flattened part of the sides, another shallow and slightly asymmetric lobe on the concave part of the sides, a subangular saddle at the umbilical shoulder, and a faint lobe on the umbilical wall. The sutures are obliterated before the umbilical seam is reached.

The siphuncle is ventral and is in contact or nearly so with the ventral wall. The septal necks are nearly straight and cylindrical and extend about 5 mm. apicad from the septum. The connecting rings are expanded and either pyriform or cylindrical. They appear to be pyriform with the small end toward the apex, but this appearance is probably largely or entirely due to the manner in which the matrix is broken away from the ventro-lateral margins of the connecting rings, which are exposed for a distance of 12 mm.

Remarks.—The distinctive features of this species are the high whorl and the revolving concave area just ventrad to the umbilical shoulder. *Solenochilus capax* (Meek and Worthen) has a similar concave zone below the umbilical shoulder, but that species has a somewhat different suture pattern than *S. bognari*, n. sp.

The species is named in honor of its collector, Mr. E. J. Bognar.

Occurrence.—The specimen was collected from the Vanport limestone in the pit of the Bolivar Clay Product Company, Bolivar, Ohio.

Repository.—Geological Museum, Ohio State University, Columbus, Ohio, no. 18730.

SOLENOCHILUS GREENENSIS Sturgeon, n. sp.
Plate 8, figure 6; plate 9, figure 3;
text figure 3A

Five specimens collected from the Hamden limestone are believed to represent an undescribed species of *Solenochilus*. None are complete, but if they do represent a single species, they supplement each other so well that many of the features of the conch can be compiled. One is a large, partly testaceous specimen that has preserved much of the outer whorl; another one that is somewhat crushed shows the spacing of the septa and the structure of the siphuncle. The other three specimens are mere fragments: one shows the nature of the umbilical shoulder and dorsolateral wall, the second shows some of the details of

surface sculpture, and the third has preserved part of the venter and side and part of the margin of the aperture.

The conch is large, subglobose, and rapidly and regularly expanding. The maximum diameter of the largest specimen must have measured at least 150 mm. from the adoral end of the venter to the opposite side. Some measurements on the conch of the large, partly testaceous specimen are as follows:

Height of whorl from dorsal depression	75.0 mm.
Maximum width of whorl	95.0 mm.
Width of lateral, revolving concave zone	18.0 mm.
Width of lateral flattened zone	22.5 mm.
Width of umbilical wall	27.0 mm.
Width of dorsal impressed zone	13.0 mm.
Depth of dorsal impressed zone	3.0 mm.
Diameter of umbilicus	25 ± mm.

It is impossible to make accurate measurements on the crushed specimen, but the width of its conch seems to be nearly the same as that of the large, testaceous specimen, and its height is obviously much reduced as shown by the broken and distorted septa.

The cross section of the outer whorl is depressed and subreniform in outline. The venter and ventrolateral surfaces of the conch are uniformly and evenly rounded and merge into each other without any line or zone of separation. The median zone of the flanks is definitely flattened but is not sharply separated from the rounded ventrolateral surface. The dorsal part of the flanks is strongly concave, and while the shoulder separating the flattened median zone from the dorsal concave zone is not angular, it is sharply rounded and actually overhangs slightly on one specimen. This overhang may have been caused by distortion during fossilization. This revolving, concave zone is made more prominent by the umbilical shoulder being elevated and carinate. The test is, moreover, thickened on the umbilical shoulder, and there is a ridge formed by the increased thickness of the test overhanging the periphery of the umbilicus. The umbilical shoulder lies about 10 mm. nearer the median plane of the conch than the shoulder that separates the flattened median zone of the side from the revolving, concave zone. The greatest width of the conch is therefore between the shoulders that separate the flattened and concave lateral zones.

The steep and nearly vertical wall of the small, deep umbilicus is slightly sigmoid, being concave below the umbilical shoulder and convex above the umbilical seam. On the average the dorsal impression is small and passes laterally without any angulation into the umbilical walls. The amount of involution increases rather rapidly in the last stages of growth shown by the present specimens, and in the crushed specimen the impressed zone attains a width of 36 mm. and a depth of 12 mm. or more, while the contact with the umbilical walls becomes subangular or even angular.

The thickness of test ranges up to 2 mm. and averages about 1 mm. The surface markings consist of rather inconspicuous, transverse lirae, whose slightly sinuous course around the conch is not fully known. Across the shoulder separating the concave from the flattened areas of the sides the lirae are nearly transverse, and on the flattened lateral areas they swing apicad and presumably outline a broad, rounded sinus across the venter. At least on the flattened flank the transverse lirae are crossed by weaker revolving lirae, and a faint reticulate pattern is formed on that area. The fragmentary specimen which has preserved part of the venter and side and part of the edge of the aperture shows an indication of the hyponomic sinus and has the edge of the aperture thickened externally into a flat ridge that is about 1.5 mm. wide and about 0.5 mm. higher than the general surface of the shell.

As far as can be observed the internal mold is smooth except for the sutures and siphuncle. The septa are far apart, and their spacing is equal to about one-fifth of the width of the whorl. Very little can be learned concerning the sutures, which are nearly transverse and slightly sinuous. There is a very shallow, broad, ventral lobe and an even fainter, broad, ventrolateral saddle. Unfortunately, the sutures cannot be traced further dorsad.

The medium-sized siphuncle is ventral in position and very near or in contact with the ventral wall. The septal necks are nearly straight, but on the ventral side they converge slightly apicad, and about 4 mm. apicad to each septum expand rather abruptly.

They extend about 5 mm. farther apicad before converging somewhat again. The long connecting rings, which are constricted at each end, are nearly cylindrical. The connecting rings are so long that each one extends apicad entirely through the septal neck of the preceding septum and contacts the preceding connecting ring. The total length of the septal necks is about 11 mm., and the total length of the connecting rings is about 21 to 22 mm., which is the entire length of one of the camerae. One of the connecting rings appears to be entirely closed at the orad end, but this is probably due to the fact that the section is not of sufficient depth to cut through the terminal constriction. The approximate diameter of the siphuncle is 7 mm.

Remarks.—The general siphuncular structure of this species is similar to that of *Solenochilus newloni* (Hyatt) from the Cherokee formation, Oswego, Kansas; to that of *S. peculiare* Miller and Owen from the Cherokee formation, Henry County, Missouri; and to that of *S. bognari*, n. sp., from the Vanport limestone, Bolivar, Ohio. The latter two species have median ventral saddles instead of a ventral lobe; and in addition *S. peculiare* has a different structure of its siphuncular segments and longitudinal lirae on the internal mold, and *S. bognari* has much longer septal necks and a less concave revolving zone below the umbilical shoulder. *S. newloni* has the greatest width of the whorl at the umbilical shoulder, no concave area below the umbilical shoulder, and shorter camerae. *S. capax* (Meek and Worthen) from the Pennsylvanian at Charboniere, Missouri, has a similar concave area below the umbilical shoulder, but as far as can be determined the siphuncle is straight and cylindrical.

The large testaceous specimen and the somewhat crushed specimen showing the siphuncle are designated as cotypes of this species. The specific name is taken from Green Township, Mahoning County, Ohio, which has yielded many of the specimens available for this study.

Occurrence.—All known specimens are from the Hamden limestone. One cotype and one paratype are from the now abandoned H. L. Dougherty mine, northeast corner, section 19, Green Township, Mahoning County; and the other cotype and a paratype are from the Brookwood mine, west-central part, section 29, Perry Township, Columbiana County. The third paratype is from the mine of the Salem Coal Company, southwest quarter, section 33, Green Township, Mahoning County.

Repository.—Geological Museum, Ohio State University, Columbus, Ohio, nos. 18731 and 18732.

NAUTILOID UNDETERMINED
Plate 8, figure 5

There is a large fragmentary specimen from the Vanport limestone at Bolivar, Ohio, whose generic affinities are uncertain. The fragment consists of about one-fourth of three different and incomplete whorls. The outermost whorl is testaceous on the umbilical wall and shoulder and on part of the flank; the features of the innermost whorl are largely unknown because of distortion, replacement, and incompleteness. One entire side of these fragmentary whorls is destroyed.

The conch is large, nautiliconic, subglobose to subdiscoidal and rapidly expanding. The whorls are deeply involute, and the outermost whorl conceals about two-thirds of the preceding whorl. The whorl cross section is slightly compressed and reniform in outline. Observations on the middle whorl show that the whorl is fairly broadly rounded ventrally and dorsolaterally, more narrowly rounded on the umbilical shoulder, flattened laterally, and deeply impressed dorsally. The lateral sides are nearly parallel but converge slightly ventrad, and the greatest width of the whorl is slightly ventrad to the umbilical shoulder.

Few measurements can be made on the outermost whorl, but the preceding whorl has the following dimensions:

Maximum width	31 mm.
Maximum height	32 mm.
Height between venter and impressed zone	22 mm.

The transverse diameter of the outer whorl is almost 80 mm., and the dorsal impressed zone is about 23 mm. deep and 28 mm. wide.

The umbilicus must have been small, steep-walled, and very deep. The umbilical wall is stepped or terraced as a result of the incomplete involution of the whorls. Each

rounded step of the umbilical wall is convex but nearly vertical above the umbilical seam except for an inward slope toward the center of the umbilicus just above the umbilical seam. This inward flare of the umbilical wall is formed by a ridgelike thickening of the test. It is impossible to determine whether the umbilicus was perforate.

The test is very thick and apparently in several distinct layers, attaining a maximum thickness of about 6 mm. on the flanks of the outer whorl. From the sides the shell thins both toward the venter and the dorsum, and on the umbilical wall the thickness is about 2 mm. As far as can be ascertained the surface ornamentation consists of numerous, fine, transverse lirae that are slightly oblique orad on the umbilical wall, but which swing apicad as they cross the umbilical shoulder. They cannot be traced farther dorsad.

In the middle whorl the septa are about 4 mm. apart, and the ratio of the width of the whorl to the septal spacing is about 7.5:1. The siphuncle lies about one-third of the distance from the dorsal impressed zone to the venter, but this position is in reality at or near the center of the cross section of the whorl. At its passage through a septum where the lateral diameter of the whorl is about 28 mm. the siphuncle has a diameter of about 3 mm. Otherwise its structure is unknown.

Remarks.—Without the ventral portion of the outer whorl, it is hazardous to speculate on the generic relationship of this specimen. It is much too large and involute to be a representative of *Liroceras*.

Occurrence.—This specimen also came from the Vanport limestone in the pit of the Bolivar Clay Product Company, Bolivar, Ohio.

Repository.—Geological Museum, Ohio State University, Columbus, Ohio, no. 18733.

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A STUDY OF TWO ARCID PELECYPOD SPECIES FROM WESTERN SOUTH AMERICA

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ABSTRACT—A revised superfamily Arcacea contains the family Arcidae, subfamilies Arcinae, Anadarinae, and Litharcinae (new), and the family Noetiidae, subfamilies Noetiinae and Striarcinae.

Litharca lithodomus (Sowerby), illustrated and described in detail, is a boring form, living on the open seacoast, ranging from Manta, Ecuador, to Cabo Blanco, Peru. A record from Panama is questioned.

Anadara (*Larkinia*) *grandis* (Broderip and Sowerby) ranges from Magdalena Bay, Lower California, and the Gulf of California to Sechura Bay, Peru. It is an ecologically restricted form, temperature controlled, living in mud flats in estuaries and embayments. Some paleoecological inferences based on the species are questioned.

INTRODUCTION

LITHARCA lithodomus (Sowerby) is one of the least-known marine pelecypods of western South America. A suite of topotype and other specimens, extending the range and permitting a detailed account of shell morphology and ecology, therefore is of special interest. Adaptation of the species to a boring habit, probably unique among the arcids, gives it an additional importance.

The discovery of Recent specimens of *Anadara* (*Larkinia*) *grandis* (Broderip and Sowerby) in Sechura Bay, Peru, extends the known range and modifies ecological interpretations.

Systematic and ecological study of these species led to a review of the supergeneric classification of the genus *Arca* and its allies. In proposing a revision of the superfamily Arcacea, I have been intentionally critical of the specialists on this group. The extreme divergence of their opinions seems to call for additional research on the classification of the arcoid pelecypods, including work by nonspecialists. It is to be hoped that the present effort will stimulate such work and publication.

Assistance in preparing this paper is acknowledged in the text. I am especially indebted to my wife, Dr. Harriet Exline Frizzell, for discussions of zoological theory and practise. Figures 1 to 6 were drawn by Miss Mary Barnas, Quito, Ecuador.

CLASSIFICATION OF THE SUPERFAMILY ARCACEA

Present status.—There is no agreement between current supergeneric classifications of *Arca*-like pelecypods.

Reinhart (1935) used the conservative arrangement of: family Arcidae, subfamilies Arcinae, Anadarinae, Noetiinae. MacNeil (1938) proposed a different classification without details except for the Noetiidae. He states:

> The arrangement here presented was arrived at as a result of some researches in the structure and evolution of the ligament of the arcid pelecypods and will be supported more fully in a paper on ligamental structure to be published soon.

MacNeil's classification is as follows:

Suborder Prionodonta, superfamilies Cyrtodontacea, Parallelodontacea, Glycymeracea, Arcacea.

Superfamily Glycymeracea, families Cucullaeidae, Glycymeridae, Naviculidae, Limopsidae, Noetiidae.

Family Noetiidae, subfamilies Striarcinae, Trinacriinae, Noetiinae.

The most obvious discrepancy between Reinhart's and MacNeil's arrangements is due to a nomenclatural snarl involving the genotype designation for *Arca*, *s.s.* Its solution awaits publication of an Opinion by the International Commission on Zoological Nomenclature (Reinhart, 1935, pp. 15–17; Schenck and Reinhart, 1938-A, pp. 13–14; MacNeil, 1942). Reinhart's Arcinae is nomenclaturally equivalent to MacNeil's Naviculidae, and the Anadarinae equivalent to the Arcinae (implicit in MacNeil's use of a superfamily Arcacea).

Reinhart's classification is objectionable because it places the distinctive *Noetia*-like

genera on an equal status with the mutually similar Arcinae and Anadarinae, and fails to separate the distinctive form *Litharca*.

MacNeil's arrangement cannot be criticized adequately until all of the details have been published. Some facts, however, are obvious: The "Arcinae" (=Anadarinae of this paper) is placed in a separate superfamily, Arcacea, while the "Naviculidae" (=Arcinae of this paper) is included with the Noetiidae in a composite super-family Glycymeracea. The members of a natural group seem to be distributed too widely, suggesting that a single character (the ligament) has been emphasized to the exclusion of other important shell characters.

Classification and nomenclature.—The first purpose of classification is to arrange organisms according to their zoological relationships; the second is to apply names to the various hierarchies which conveniently express the relationships. The problem in dealing with supergeneric categories, therefore, is two-fold: to establish genetic groups and to apply generally intelligible names to those groups. Relationships may be inferred from morphological data or from assumed evolutionary trends; nomenclature is a more arbitrary matter.

The morphological approach to pelecypod classification has been used generally by zoologists and conchologists. Classifications have been based upon internal anatomy ("soft parts") and upon shell characteristics, stressing a single character or using several characters. Internal anatomy is inadequate as a basis for classification because it can be applied only to living forms and it demonstrates the development of the class only by implication. No "soft-part" classification yet proposed can be applied to all of the categories from species upward. A classification based upon shell characters therefore is essential.

Single-character classifications are being replaced by the method of summation of characters (Frizzell, 1936, pp. 3–6; Schenck and Reinhart, 1938, p. 313). The interrelationships of a number of morphological characters constitute the most satisfactory clues to the problem of classification. The inferences based upon these characters, however, should be substantiated by other lines of evidence. Chronogenesis and path of evolution should be considered, and even such factors as habit and physiology. If this is done, the morphological approach verges upon the evolutionary.

It cannot be assumed in this method that all characters are of equal classificatory value. On the contrary, they must be weighted according to their potential plasticity during evolutionary processes. For the Pelecypoda, shell characters appear to be of value in somewhat the following order: (1) shell structure, (2) dentition and ligament, (3) pallial impression and muscle scars, (4) shape, and (5) external ornamentation. I do not agree with Schenck and Reinhart (1938, p. 313), for example, in their opinion that form and sculpture, in the arcoid genus *Striarca*, outweigh the characters of muscle scars and ligamental grooving.

The evolutionary approach to pelecypod classification was used first by Douvillé and expanded by Davies (1935), but applied only to superordinal "branches." Superfamilies and lower categories were based upon comparative morphology. MacNeil (1938) has used this approach, in conjunction with morphological evidence, in his study of the Noetiidae. Some of the objections to his conclusions have been discussed by Reinhart (1943).

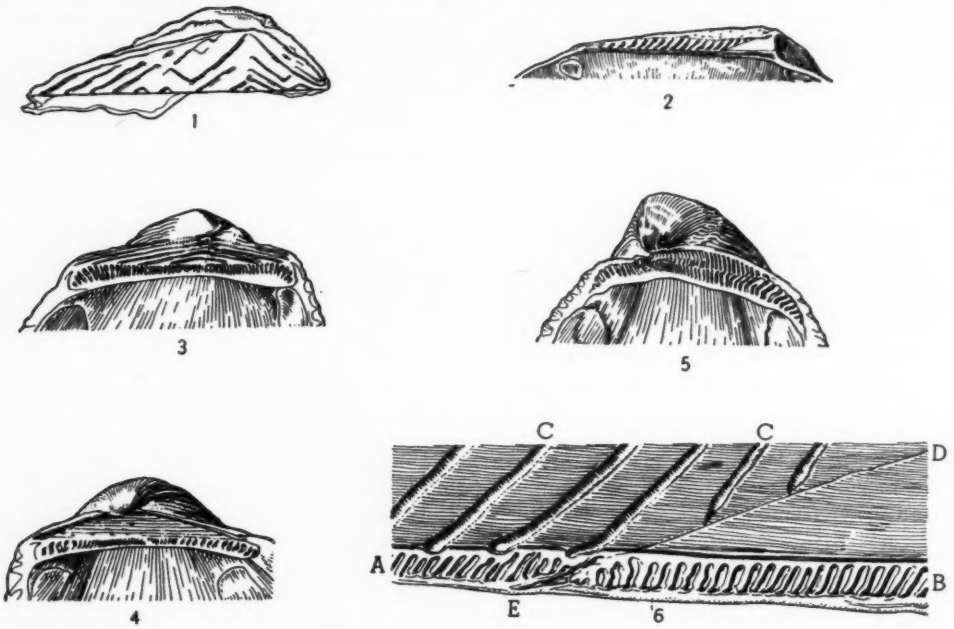
Regardless of whether the biological approach is morphological or evolutionary, classificatory nomenclature must express the postulated relationships. I believe that this is best accomplished through the use of narrowly defined families and subfamilies within compact superfamilies (compare Frizzell, 1936, Veneracea).

Structure and significance of ligamental grooves.—The grooves of the ligamental area, a conspicuous feature of the arcoid shell (figs. 1–5), have been stressed in classification by MacNeil (1938) and ignored by Reinhart (1935). Ligamental grooves are lateral, chevron-shaped, oblique, and transverse (vertical). If the position and shape of the grooves is assumed to be a unit character, intergradation between the different types would be expected, and the character would have little importance in supergeneric classification. The assumption, however, must be questioned.

The structure of the ligament is beyond

the scope of this study,[1] but the ligamental grooves are treated as characters of the shell and considered in relation to the other characters of the hinge plate. Thin sections of *Arca* (*A.*) *pacifica* (Sowerby) and *Noetia* (*N.*) *reversa* (Sowerby), as well as eroded specimens of these and other species, show that hinge teeth grow by accretion and remain their structure in the older part of the hinge plate. Forms with lateral, chevron-shaped, and oblique ligamental grooves have the older hinge structure covered by a layer of shell material, in which the grooves are excavated. In forms with transverse grooves, on the other hand, the so-called ligamental grooves are interspaces between the ridges formed by the uncovered tops of the dental elements. In *Noetia*, *s.s.*, the posterior dental elements are covered by a layer of shell material; the anterior dental elements are uncovered and form the grooves. A modification is shown in the genotype of *Striarca* (Schenck and Reinhart, 1938, fig. 11), in which nearly the entire hinge has uncovered dental elements.

The systematic importance of ligamental grooves is shown by the dual division, which parallels the classification based upon other characters. Most of Reinhart's arcine and anadarine genera have lateral, chevron-shaped, or oblique grooves, the Noetiinae having transverse grooves. The morphological difference therefore seems to be of classificatory importance.



FIGS. *1–5*—Arcoid pelecypods, showing patterns of the ligamental grooves. *1*, *Arca* (*Arca*) *pacifica* (Sowerby) intergradation between chevron-shaped and oblique. *2*, *Litharca lithodomus* (Sowerby), oblique. *3*, *Anadara* (*Anadara*) *tuberculosa* (Sowerby), chevron-shaped. *4*, *Anadara* (*Anadara*) *antiquata* (Linnaeus), lateral (redrawn from Schenck and Reinhart, 1938a, pl. 6, fig. 3). *5*, *Noetia* (Noetia) *reversa* (Sowerby), transverse grooves showing relationship to hinge teeth.
6—*Litharca lithodomus* (Sowerby). Sketch of part of ligamental area and hinge line, approximately ×6. *A*, Anterior teeth; *B*, posterior teeth; *C*, ligamental grooves; *D*, incised line of ligament; *E*, groove across hinge forming a continuation of the incised line.

Revised classification.—Applying the principle of summation of characters, I regard the genus *Arca* and similar forms as a distinct superfamily. Available evidence indicates that they agree in shell structure, dentition, internal markings, shape, and ornamentation. Structure of the ligamental area,

[1] An excellent account of the arcoid ligament is given by Newell (1937, pp. 26–33; 1942, pp. 26–29).

however, divides them into two major groups. Inasmuch as these groups are too widely separated in MacNeil's (1938) superfamily arrangement, and too closely joined in Reinhart's (1935) family classification, I suggest a restricted superfamily Arcacea to include the two groups.

The modified classification which follows is adapted largely from the arrangements of Reinhart and MacNeil. The Litharcinae is proposed as a new subfamily in the Arcidae, and is defined on a later page. MacNeil's subfamily Trinacriinae is removed from the Noetiidae (compare Davies, 935, pp. 173–174). To make the nomenclature intelligible, genotypic species of type genera are included in the tabulation. Other interpretations, although not changing the biological relationships, would give different names to some of the families and subfamilies (Reinhart, 1935, pp. 15–17; Schenck and Reinhart, 1938-A, pp. 13–14; MacNeil, 1942).

CLASSIFICATION OF THE SUPERFAMILY ARCACEA

Family Arcidae—ligamental grooves lateral, chevron-shaped, or oblique; incised in shell material covering the dental elements.
- Subfamily Arcinae—*Arca noae* Linnaeus (1758, p. 693) (Reinhart, 1935, p. 14).
- Subfamily Anadarinae Reinhart, 1935—*Arca antiquata* Linnaeus (1758, p. 694) (Reinhart, 1935, p. 39).
- Subfamily Litharcinae (new)—*Byssoarca lithodomus* Sowerby (1833, p. 16).

Family Noetiidae MacNeil, 1938—Ligamental grooves transverse; lying between exposed dental elements.
- Subfamily Noetiinae Stewart, 1930—*Noetia triangularis* Gray (1857, p. 371) (=*Arca reversa* Sowerby, 1833, p. 20) (Reinhart, 1935, p. 48).
- Subfamily Striarcinae MacNeil, 1938—*Arca centenaria* Say (1824, pp. 138–139, pl. 10, fig. 2) (Schenck and Reinhart, 1938).

DISCUSSION OF SPECIES

Superfamily ARCACEA

Family ARCIDAE

Subfamily ANADARINAE Reinhart, 1935

Genus ANADARA Gray, 1847

Subgenus LARKINIA Reinhart, 1935

ANADARA (LARKINIA) GRANDIS (Broderip and Sowerby)

Arca grandis BRODERIP and SOWERBY, 1829, Zool. Jour., vol. 4, p. 365.

Arca (*Anadara*) *grandis* Sowerby. DALL, 1909, U. S. Nat. Mus. Proc., vol. 37, pp. 154, 253.

Arca (*Scapharca*) *grandis* Broderip and Sowerby. MAURY, 1922, Palaeontographica Americana, vol. 1, no. 4, pp. 32–33, pl. 3, fig. 13 (with synonymy).

Anadara (*Larkinia*) *grandis* (Broderip and Sowerby). Reinhart, 1935, Mus. royal histoire nat. Belgique Bull., tome 11, no. 13, p. 41; 1943, Geol. Soc. America, Special Papers 47, pp. 65–66, pl. 13, figs. 4–6.

Material.—Three specimens were collected in November, 1941, during a half hour spent at the mouth of Brazo Ramon, an estuary some 25 kilometers south of the village of Sechura, Peru (index map, fig. 7). Two separate valves and a complete shell are in storage and not available for

FIG. 7—Sketch map of part of the coast of Ecuador and Peru.

description. The discussion therefore is based upon collecting notes.

The widespread occurrence of *A. grandis* in Pleistocene deposits in the area suggests that these specimens are reworked fossils. Several facts, however, indicate a Recent origin: (1) The shells have a porcellanous luster within, not seen in Pleistocene fossils in the region. (2) The complete specimen is free of matrix, except for a slight amount on the exterior. Numerous dead shells of a burrowing pelecypod (*Tagelus* sp.), in their normal position in the intertidal substratum at the locality, were nearly all covered with an identical hard, sandy matrix. The presence of matrix, therefore, is not evidence of fossilization. (3) The mouth of Brazo Ramon fulfills the ecological requirements of the species, that is, intertidal mud and sandy mud flats, with warm, estuarine water.

Distribution.—Magdalena Bay, Pacific Coast of Lower California (lat. 24° 35′ N.), and Guaymas, Gulf of California (lat. 27° 55′ N.), south to Brazo Ramon, Department of Piura, Peru (lat. 5° 47′ S.).

Anadara grandis has been reported from Magdalena Bay to Tumbez, Peru (Dall, 1909, pp. 154, 253; Maury, 1922, pp. 32–33), with records northward to Guaymas, Mexico (Stearns, 1894, p. 147; Pilsbry and Lowe, 1932, p. 140), and southward to Zorritos, Peru (Olsson, 1924). The occurrence at Brazo Ramon extends the known range southerly approximately 2° 08′ of latitude, or some 254 kilometers. This extension is partly confirmed by Peile (in Bosworth, 1922, p. 178), who included *A. grandis* in a list of species now ranging both north and south of Negritos, Peru.

The geological range of the species has not been established. It is reported from Pliocene deposits in the Gulf of California (Grant and Gale, 1931, p. 141) and is present in the marine terraces of northwestern Peru, having ranged at least as far south as Sechura Bay during Pleistocene time.

Ecology.—Detailed physical-chemical data as a basis for ecological interpretations are not available. Some conclusions may be drawn, however, from the information in table 1.

Water temperature is the first factor controlling occurrence. Tumbez, the southern limit of abundant specimens, is situated near the end of the area affected by the warm Panama Current (El Niño). Sechura Bay, including Brazo Ramon, is an anomalous warm locality within the limits of the cold Humboldt Current. Similarly, in its northern range *A. grandis* extends into the warm waters of the Gulf of California, north of its limit on the Pacific coast of Lower California.

The second ecological requirement is an estuary or partly inclosed embayment. Available records and observations show that the species is absent from the open seacoast.

A mud or muddy substratum is typical, although records from western Mexico show that the species is not restricted to that facies. A mangrove-swamp environment is closely correlated with common to abundant occurrence, but the relationship probably is largely fortuitous. The occurrence at Brazo Ramon indicates that a suitable temperature and sheltered embayment might permit *A. grandis* to thrive in an arid region without mangrove swamps. Probably the scarcity of the species between Tumbez and Brazo Ramon is due chiefly to the lack of estuaries or sheltered embayments in the intervening area.

Paleoecological significance in the Pleistocene of northwestern Peru.—The Quaternary marine deposits of northwestern Peru consist of four terraces with their beds, termed tablazos (Bosworth, 1922, pp. 143–268; Werenfels, 1927, pp. 474–477). The Mancora tablazo is oldest. It has been referred to the Pliocene (Olsson, 1932, pp. 42, 62) but is regarded here as not older than middle Pleistocene. The Talara and Lobitos tablazos and the "Salina plain" follow in decreasing order of age. These terraces are especially well developed near the town of Negritos but are conspicuous topographic features along much of the Peruvian coast and are present also on the coast of Ecuador.

Published records of the tablazo molluscan faunas are scant. Bosworth (1922, pp. 174–178) listed 48 species from the combined Mancora, Talara, and Lobitos tablazos, identified by A. J. Peile. Dall (1909, pp. 189–190) listed 253 species common to the Panamic and Peruvian molluscan provinces, and 239 Panamic species ranging to the vicinity of Cabo Blanco. Bosworth's faunal

lists, therefore, are too small for quantitative comparison. Some other approach to the problems of Pleistocene paleoecology in the region is needed.

Olsson (1932, pp. 62–63) has stressed the ecological significance of *Anadara grandis*. He concluded that:

> As shown by Guppy, the distribution of the mangrove-swamp vegetation of Ecuador has a direct relationship to annual rainfall. At the present time, mangrove finds its southern limit at Tumbez. There are several species of mollusks which are restricted to a mangrove-swamp habitat, amongst which is *Arca* (*Senilia*) *grandis* Broderip and Sowerby, the Pata de Burro of the Peruvians is the most important. In the Recent fauna, the southern limit of this species is Tumbez. *Arca grandis* washed from cliffs of Pleistocene sands, cover the upper part of the beach. The range of this species was therefore much more extensive in Pleistocene times than at present and a climate at least as humid as that of Tumbez existed in the Sechura district or approximately 200 miles beyond the present southern limit of mangrove vegetation.

These inferences are open to question on several grounds. If the specimens of *Anadara grandis* from Brazo Ramon are of Recent origin, the present southward range is co-

grandis is a common fossil in the Peruvian tablazos and its distribution is therefore a guide to the former, greater extension of mangrove-swamp conditions during the Pleistocene and late Pliocene times. Along the south shore of the Bay of Sechura east of Bayovar, the fossil shells of *Arca*

TABLE 1. ECOLOGICAL DATA FOR ANADARA GRANDIS (BRODERIP AND SOWERBY)

Locality	Approx. Lat.	Source of data	Marine facies	Shore facies	Substratum	Water temperature	Abundance
Magdalena Bay, Lower Calif.	24° 35′ N.	L. W. Wiedey[1]	Predominantly inclosed embayment	Mangrove	Intertidal mud	Warm	Abundant
Western Mexico and Central America	—	Pilsbry and Lowe[2]	Embayment	—	Sand bars at extreme low tide	Warm	"Not rare"
Panama	8° 29′ N.	Maury[3]	Estuarine; embayment	Presumably mangrove	Intertidal mud	Warm	Common to abundant
Buenaventura, Colombia	3° 50′ N.	J. G. Marks[4]	Estuarine	Mangrove	Intertidal mud	Warm	—
Puná Island, Ecuador	3° 00′ S.	D. L. F.[5]	Estuarine	Mangrove	Intertidal mud	Warm	Apparently common to abundant
Tumbez, Peru	3° 30′ S.	Dall[6]	Estuarine	Mangrove	Intertidal mud	Warm	Common
Brazo Ramon, Peru	5° 47′ S.	D. L. F.[7]	Estuarine	Desert	Intertidal mud	Warm	—

[1] L. W. Wiedey, Negritos, Peru, gives the following description of Magdalena Bay (personal letter dated November 2, 1942): " . . . the coastal topography resembles that around San Francisco Bay [California], in that the coastline is rugged, being bordered by low coastal ranges that parallel it. In addition, the entrance to the bay has a width of one to two miles with a considerable expanse of water behind it. Unlike the California counterpart, the main body of water trends north, instead of south but, similar to the California counterpart, it is adjoined on the east by a low coastal plain, west of hills and mountains that lie farther toward the east. . . . the environment . . . was more typically mangrove, with low tidal mudflats that were exposed periodically; . . . On some of the mudflats . . . we collected two or three large sacks of bivalves, and most of these were an *Arca* of large size [*Anacera grandis*]. . . . "

Michelbacher and Ross (1942, p. 10) say of the adjacent Magdalena Plain: "This low, silty plain gently sloping westward has apparently resulted from the deposition of sand and silt from the mountains to the east." There are " . . . a number of large arroyos originating in the sierra to the east across the plain, along which there are dense growths of mesquite. A characteristic feature of the plain is the very numerous, shallow, dry lake beds, which are generally devoid of vegetation."

[2] Pilsbry and Lowe (1932, p. 140); La Paz; Guaymas; Mazatlan; Salina Cruz (Mexico). Puntarenas (Gulf of Nicoya) Gulf of Fonseca.

[3] Maury (1922, pp. 32–33) reported the species from intertidal mud at the following localities: mouth of the Rio Chepo; San Miguel, Rey Island, Panama Bay.

[4] J. G. Marks, Guayaquil, Ecuador (personal communication, October 25, 1942), purchased specimen said to occur in intertidal mud in the estuary of the Bay of Buenaventura.

[5] Puná Island, at the mouth of the Guayas River, is predominantly a mangrove swamp area, with estuarine conditions and a chlorinity varying through a presumably wide range due to the alternating effects of tides and fresh water from the river; J. G. Marks reports the species abundant in intertidal mud.

[6] Dall (1909, pp. 154, 253) listed the species as common in the mud about mangrove roots at Tumbez, and northward in the estuarine swamps of the Gulf of Guayaquil.

[7] Brazo Ramon is an elongate, narrow estuary, 2 to 3 kilometers across at the widest part, beginning about 25 kilometers south of the village of Sechura, Peru, and extending roughly 15 kilometers southeasterly into the Sechura Desert. Equinoctual high tides flood the estuary 10 to 15 kilometers east of its normal end. The flooded area dries slowly, leaving a series of salt marshes in its wake. During the periodic years of heavy rain in the region, the Piura River is said to leave its normal course and to overflow into Lake Ramon, thence into the estuary of Brazo Ramon. The ecological situation at the mouth of the estuary is one of variable chlorinity, warm shallow water, and wide intertidal mudflats.

extensive with the known limit in the Lobitos tablazo deposits. The validity of the species as an index to terrestrial climate has been questioned in the discussion of ecology. From the viewpoint of paleoecology, it is significant that Maury (1922, pp. 32–33) regarded *Anadara patricia*, the Caribbean Miocene analogue or immediate ancestor of *A. grandis*, as having lived in an environment of aridity and near-shore conditions. This interpretation, although in contrast to that generally accepted for *A. grandis*, fits the present ecological situation for Brazo Ramon.

The topography of the region presents an additional line of evidence against the existence of a humid Pleistocene climate. The Mancora tablazo extends from south of Paita some 115 kilometers northward to the village of Mancora, with a very slightly dissected surface. In a humid climate, this extensive terrace surface could not have been preserved so nearly intact. The extensive erosion of tablazo surfaces and deposits in western Ecuador, largely under humid conditions, may be taken for comparison.

An alternative hypothesis is compatible both with a mangrove-swamp environment in the Sechura Desert area during Lobitos tablazo time, and with the topography of the Mancora tablazo. This assumes the existence of an estuary or largely inclosed embayment, comparable to some now in existence.

The estuary of the Guayas River of southwestern Ecuador and the Gulf of Guayaquil are bordered by typical mangrove swamps, with *Anadara grandis* common to abundant in intertidal mudflats. The Santa Elena Peninsula immediately to the north is a desert area, forming an outlier of the extensive Peruvian desert system. Manta, still farther to the north, is semiarid, and markedly unlike the nearby humid areas.[2] At Magdalena Bay, Lower California, mangrove swamps exist in a semiarid region. Similar closely spaced but radically distinct ecological niches may have been present along the Peruvian coast during parts of Pleistocene time.

[2] Wolf (1892, map II) has illustrated these anomalies of rainfall and vegetation. Mangrove swamps are shown by stippling and small circles, but not indicated in the legend.

These anomalies of environment emphasize an important point in paleoecology: The local environment of a facies-controlled marine mollusk is much more significant than its over-all range. The geographic range of *A. grandis*, for example, is an index only to the temperature of the water; specific occurrences indicate estuaries or predominantly inclosed embayments, with intertidal mudflats or sand bars.

Subfamily LITHARCINAE Frizzell, new subfamily

Type genus, *Litharca* Gray, 1842 (Syn. Brit. Mus., ed. 44, p. 81), replacing the *nomen nudum Litharea* [typ. err] Gray, 1840 (Syn. Brit. Mus., ed. 42, p. 151).[3] *Litharca* was a genus without species. The genotype, *Byssoarca lithodomus* Sowerby, is the first species referred to the genus, allocated by Gray in 1847 (Reinhart, 1935, p. 18). This selection is automatic (International Commission on Zoological Nomenclature, Opinion 46, Schenk and McMasters, 1936), and not a case of subsequent designation.

Diagnosis.—Arcid pelecypods of boring habit; shell cuneiform, strongly inequilateral (produced anteriorly), slightly inequivalve (right valve thicker), byssal gape much reduced; beaks slightly opisthogyrate; ligament anterior, with oblique grooves; hinge line nearly straight; inner margin obsoletely crenulate.

The Litharcinae resemble the Arcinae in the straight hinge line, the oblique ligamental grooves incised in a layer of shell material, and in the presence of a byssal gape. The subfamily differs in habit and in the restriction of the ligament to the anterior part of the cardinal area. It somewhat resembles the Noetiidae, but has different ligamental grooves and somewhat different muscle scars.

Discussion.—*Litharca* Gray has been treated variously by systematists (Maury, 1921). Maury (1922, pp. 7–8) recognized the validity of the name, referring it to a "section" of *Arca, s.s.* Reinhart (1935, p. 18; 1943, p. 27) raised *Litharca* to subgeneric rank under *Arca, s. l.*

Allocation of a markedly divergent species

[3] References from Schulze (p. 1871), furnished by A. Myra Keen, Stanford University, California.

depends largely upon the prejudices of the reviser. It may be regarded as aberrant and included with presumably related groups, or considered to be a unique member of an ascending order of categories from species to subfamily or higher rank. Both the morphological and evolutionary taxonomic methods have been applied to *Litharca lithodomus* in deciding upon a plausible supergeneric position. The validity of *Litharca* as a genus is too obvious for discussion.

The morphological approach shows that the genus is arcid in presumed shell structure, ligamental grooving, adductor muscle scars, byssal gape, and sculpture; it resembles the Noetiidae only in the anterior ligament and produced anterior end. These homologies strongly suggest allocation to the family Arcidae. The shape and anterior ligament, however, argue subfamily separation from the Arcinae and the Anadarinae.

The evolutionary approach indicates that *Litharca* is an arcid genus which has become adapted to a boring habit. Modifications are in the shortened posterior and greatly elongated anterior end, the posterior reduction and slight forward movement of the ligament, and the reduction of the byssal gape.

Litharca might be considered an extremely late modification of *Arca, s.s.*, inasmuch as there are no fossil records of the genus. The apparent lack of fossils, however, should not be overstressed. The delicacy of the shell prevents its preservation in beach drift, a reason for the extreme rarity of the species in Recent collections. Individuals may have been preserved as fossils within their borings. In strand-line deposits, however, rock-boring mollusks are difficult both to find and to extract from the matrix. The lack of records of fossil *Litharca* therefore cannot be given any great taxonomic importance.

Both the morphological and evolutionary approaches indicate that *Litharca* constitutes a monogeneric subfamily within the Arcidae. *Litharca lithodomus* seems to be morphologically distinct from the recognized subfamilies, which appear to form reasonably compact groups. The boring habit appears to be unique in the family and supports the evidence of shell morphology as a basis for subfamily separation. As a practical measure, recognition of the Litharcinae should emphasize the unity of the other subfamilies.

Genus LITHARCA Gray, 1842
LITHARCA LITHODOMUS (Sowerby)
Plate 10, figures 1–5; text figures 2, 6

Byssoarca lithodomus SOWERBY, 1833, Zool. Soc. London Proc., vol. 1, p. 16.

Arca (Litharca) lithodomus (Sowerby) (in part only, Panama occurrence may be distinct). MAURY, 1922, Palaeontographica Americana, vol. 1, no. 4, pp. 7–8 (with synonymy). REINHART, 1935, Mus. royal histoire nat. Belgique Bull., tome 11, no. 13, p. 18; 1943, Geol. Soc. America, Special Papers 47, p. 27, pl. 11, figs. 1–4.

Arca lithodomus (Sowerby). OLSSON, 1924, Nautilus, vol. 37, pp. 120–130.

Type locality.—*Litharca lithodomus* was described from Montecristi, Province of Manabí, Ecuador (lat. 1° 00′ S.). Montecristi, however, cannot be the type locality, since that town is inland, some 12 kilometers south of the Bay of Manta and about 30 kilometers east of Cape San Lorenzo. The type locality therefore is considered to be that part of Manta Bay closest to Montecristi; that is, from Jaramijó Point westward beyond the town of Manta.

The coast line west of Manta consists of sea cliffs at highest tide, with a gently sloping sand and gravel beach, and flat sandstone ledges exposed at lowest tide. Occasional rocky points extend beyond low-tide level. *Litharca lithodomus* was found just above the rock ledges. Usually several valves were found relatively close together, suggesting an origin in a nearby colony. No living specimens were found.

Type material.—The holotype is believed to be in the British Museum (Natural History), London. Hypotypes will be deposited in the California Academy of Sciences, San Francisco, California, and topotypes sent to other institutions in the United States.

The present discussion is based upon 36 topotypes, exclusive of fragmentary specimens, with the locality data: Beach from 1 to 3 kilometers west of Manta, Province of Manabí, Ecuador; 28 specimens collected by D. L. and H. E. Frizzell, June 1–7, 1942, the remainder by O. L. Haught, January, 1943.

Range.—Panama? (Maury, 1921, 1922; Reinhart, 1943); Manta, Ecuador, to Cabo Blanco, Department of Piura, Peru (col

lected by Mr. and Mrs. C. J. C. Ewing, El Alto, Peru).

Additional records are Salinas, Ecuador (Olsson, 1924), and Manglaralto, Ecuador (O. L. Haught, collector, collection of J. G. Marks). Until more material is available, the specimen from Panama will be referred only questionably to this species; reasons are discussed in the section on variation.

Ecology.—Litharca lithodomus has not been reported alive since its proposal. Sowerby's statement, evidently from Cuming's field notes, is: "Found in holes in stones, pierced by *Pholades?* at low water."

Reeve (1844, pl. 12, fig. 76) concluded that:

> This extraordinary species of *Arca* most probably becomes imbedded in stones and masses of rock by the aid of some powerful solvent secretion, like the *Lithodomi* and other terebrating mollusks.

Dall (1898, p. 615) regarded the species as a form distorted through accidental growth in a *Lithodomus* boring, a type of distortion common in nestling and attached pelecypods.

Maury (1921; 1922, pp. 7–8) recognized the validity of *L. lithodomus*, correctly considering the shape and sculpture to be characteristic of a boring form.

The boring habit of the species is established by: (1) the field notes published by Sowerby; (2) the shape and sculpture, which strongly suggest a boring habit; (3) the lack of distortion characterizing accidental growth within borings and crevices; (4) the scarcity of attached organisms such as bryozoa, worm tubes, and barnacles, which commonly cover nestling pelecypods; when present, they are restricted to the posterior and posterodorsal areas; and (5) the restriction of dead shells to beach areas just above rock ledges containing other boring pelecypods.

Litharca lithodomus requires warm water (as indicated by its geographic range), an open-sea environment, and a rock substratum soft enough to permit penetration by the embryonic shell.

Shell morphology.—Shell of medium size, elongate cuneiform, slightly inequivalve (right valve more inflated), strongly inequilateral (produced anteriorly), inflated at posterior ridge and sloping evenly to the very thin anterior end, with a very narrow byssal gape; beaks blunt and slightly opisthogyrate. Posterior end very short, excavated below beaks and pouting near ventral margin; posterior slope of each valve bounded by a sharp ridge running from the umbo to the ventral margin and forming an acute angle with the central part of the shell; posterior margin truncate to pointed. Anterior end long; dorsal and ventral margins nearly straight for about the central three-fifths of the shell, sloping evenly to the pointed anterior end.

Surface of shell typically eroded and pitted by boring organisms, except on posterior slope and near ventral margins. Sculpture on central and anterior portions composed of numerous concentric laminae about 0.15 mm. wide and overlapping at intervals of some 0.4 mm., with inverted triangular apophyses of shell material; apices of triangles about 1.8 mm. apart in adult shell, but variable; lines of successive apophyses form the conspicuous frilled radial pseudoribbing characteristic of the adult shell. On the posterior slope are some 20 to 25 radial pseudoribs, formed by thickening of the concentric laminae, but closely spaced and lacking the triangular apophyses. In the older part of the shell, where eroded, they sometimes appear to be true radial ribs. The pseudoribs of the posterior slope bifurcate as they approach the ventral margin. Epidermis buff-brown, consisting of very numerous, concentric, paper-thin lamellae, about 2.0 mm. wide, with serrate outer edges; serrations toothlike, about 0.2 mm. high, with roughly eight serrations to a millimeter.

Ligament anterior to beaks, occupying the central three-fifths of the shell length; ligamental area broadly U-shaped at the posterior end, curving to a sharp V shape at the anterior end; ligament black, with longitudinal growth striae and oblique ligamental grooves. In some specimens, a fine incised line descends anteriorly from the beak, reaching the hinge line at about one-quarter its length from the posterior end; no grooves are present posterior to this line; in other specimens the incised line is not present. Anterior to the incised line is a series of oblique ligamental grooves slanting downward posteriorly, increasing in number with age and reaching a maximum of 20 in

specimens examined. The posterior two to four grooves usually terminate at the incised line, although in a few cases all grooves reach the hinge line. The ligamental grooves are inclined at an angle of approximately 40°, sometimes changing direction to curve upward to the dorsal margin. Rarely a specimen will show one or two grooves slanting downward posteriorly.

Inner ventral margins crenulate in young specimens, with nearly obsolete crenulation in adults. Pallial line entire; in adult shell roughly 1.0 mm. from anterior and posterior margins, 2.0 mm. from ventral margin; continuous from hinge line, completely inclosing adductor muscle scars. Anterior adductor muscle scar obovate to elliptical, directed slightly posteriorly. Some specimens show a "halo" below and in front of the anterior adductor; the cause of this mark, which appears to be due to attachment of the mantle, has not been determined. Posterior adductor scar subcircular, larger than anterior; typically forward of and touching line of posterior ridge. Anterior retractor scar elliptical, directed slightly posteriorly, about half-way between anterior adductor and hinge line. Posterior retractor scar elongate, moderately narrow, touching pallial line, extending from hinge line roughly half-way to postero-ventral angle.

Hinge line narrow and nearly straight, about 1.2 mm. wide in adult. Dentition taxodont, showing considerable variation in details, teeth usually broken and badly worn. Teeth small, recurved, elevated; increasing in number with age, ranging from 75 in a young shell (32.5 mm. long) to at least 140 in an adult; sometimes bifid and trifid; sides of teeth with rugosities ranging from fine to coarse, typically about 12 to 1 mm. The posterior and anterior four to six teeth usually form arcs downward; between, the teeth slant in various directions, and frequently are bent laterally.

Maximum length 91.1 mm. in the series of topotypes studied; other dimensions are shown in table 2. The only complete specimen (pl. 10, figs. 2, 5) is 79.1 mm. long, 25.5 mm. high, with a diameter of 23.0 mm.; the

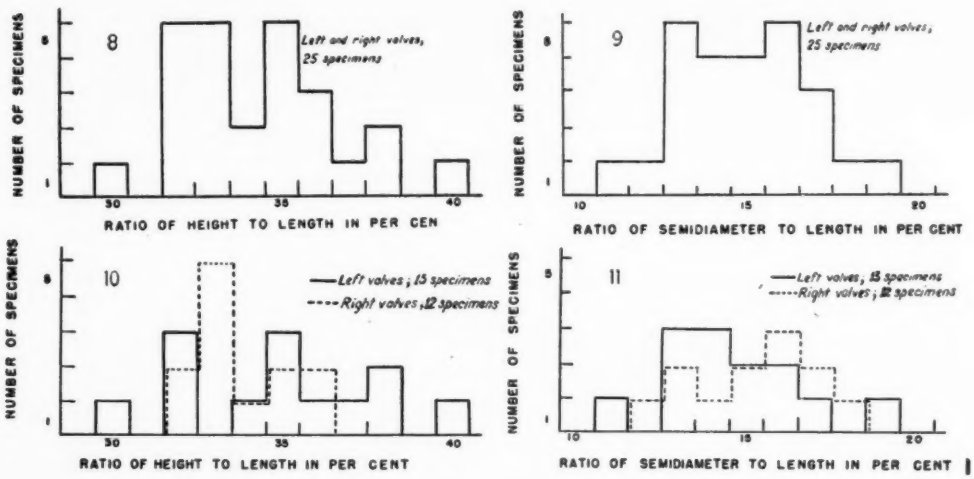
TABLE 2. DIMENSIONS OF 25 TOPOTYPES OF LITHARCA LITHODOMUS (SOWERBY)

Valve	Length (mm.)	Height (mm.)	Semidiam. (mm.)	Height / length (Percent)	Semidiam / length (Percent)
Right	27.9	9.7	4.6	35	16
Right	29.8	10.2	5.4	35	18
Right	32.2	10.7	5.0	33	16
Right	32.5	11.0	5.5	34	17
Left	35.4	14.3	6.6	40	19
Left	38.2	13.8	6.3	36	16
Right	39.9	13.3	5.8	33	15
Right	42.6	13.6	5.5	32	13
Right	44.4	16.0	7.1	36	16
Left	47.2	16.6	7.0	35	15
Left	49.2	17.4	6.9	35	14
Left	51.6	18.9	8.1	37	16
Left	51.6	19.6	8.8	38	17
Left	60.5	21.1	8.6	34	14
Right	69.4	23.0	10.1	33	15
Right	69.6	22.2	8.7	32	12
Right	69.8	22.9	9.9	33	14
Right	70.6	23.3	9.2	33	13
Left	70.9	21.2	8.9	30	13
Left	71.1	27.1	10.0	38	14
Left	71.2	23.0	9.6	32	13
Right	78.2	28.2	13.6	36	17
Left	81.0	26.0	10.6	32	13
Left	83.3	28.8	12.3	35	15
Left	91.1	29.2	10.0	32	11

semidiameter of the left valve is 10.7 mm., of the right valve 12.3 mm. A broken specimen collected at Manta by O. L. Haught has a height of 37.4 mm. The proportions plotted in figure 8 show that this specimen must have had a length from 94 to 125 mm., almost certainly nearer the latter (fig. 13). This must be about the maximum size for the species.

til they reach the base of the hinge and the groove disappears. From two to six teeth on each side of the groove are affected.

The significance of the incised line and its prolongation across the hinge, is this: If *Litharca* is derived from arcid ancestors, its immediate progenitors should have had dentition both posterior and anterior to the beaks, as well as chevron-shaped ligamental

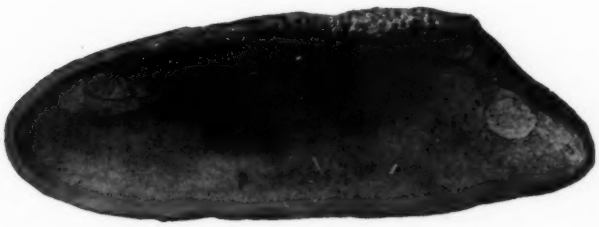

8
Left and right valves, 25 specimens
NUMBER OF SPECIMENS
RATIO OF HEIGHT TO LENGTH IN PER CEN
9
Left and right valves; 25 specimens
RATIO OF SEMIDIAMETER TO LENGTH IN PER CENT
10
Left valves; 13 specimens
Right valves; 12 specimens
RATIO OF HEIGHT TO LENGTH IN PER CENT
11
Left valves; 13 specimens
Right valves; 12 specimens
RATIO OF SEMIDIAMETER TO LENGTH IN PER CENT

FIGS. *8–11*—Variation in the shape of *Litharca lithodomus* (Sowerby). *8*, Distribution of ratios of height to length; *9*, distribution of ratios of semidiameter to length; *10*, distribution of ratios of height to length of right and left valves; *11*, distribution of ratios of semidiameter to length of right and left valves.

Evolutionary changes to fit a boring habit.—The incised line of the ligament is a character of considerable morphological importance (fig. 6). A number of specimens show division into posterior and anterior teeth. In these, a continuation of the incised line crosses the hinge and descends anteriorly. The posterior teeth decrease in size when they reach this groove, ending as tubercles abutting against its lower side. The anterior teeth begin as tubercles above the groove, increasing in size as it slants downward, ungrooves. Evolution to fit a boring habit, with the accompanying shortening of the posterior end, could have taken place in one of two ways, either by an elimination of the posterior teeth or by a mechanical shortening and coalescing of the original hinge line. The character of the dentition strongly suggests a mechanical deformation: the entire shell has been rotated, bringing the posterior teeth in front of the beaks, and literally forcing some of the posterior teeth to underride anterior teeth. If this

EXPLANATION OF PLATE 10

FIGS. *1–5*—*Litharca lithodomus* (Sowerby). Topotypes from Manta, Ecuador, collected by O. L. Haught. *1*, Interior of right valve; length, 70.4 mm. *2*, *5*, Posterior and oblique views of complete shell; length, 79.1 mm. *3*, Exterior of left valve, showing typically eroded surface; length, 78.3 mm. *4*, Interior of left valve; length, 65.8 mm. (p. 45)



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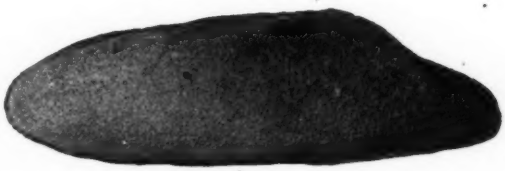

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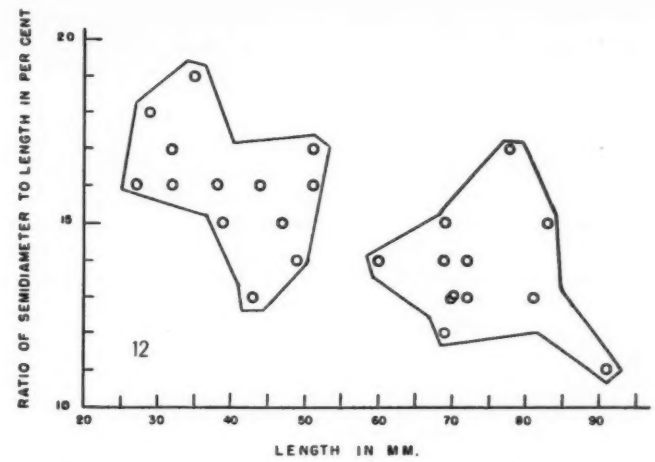
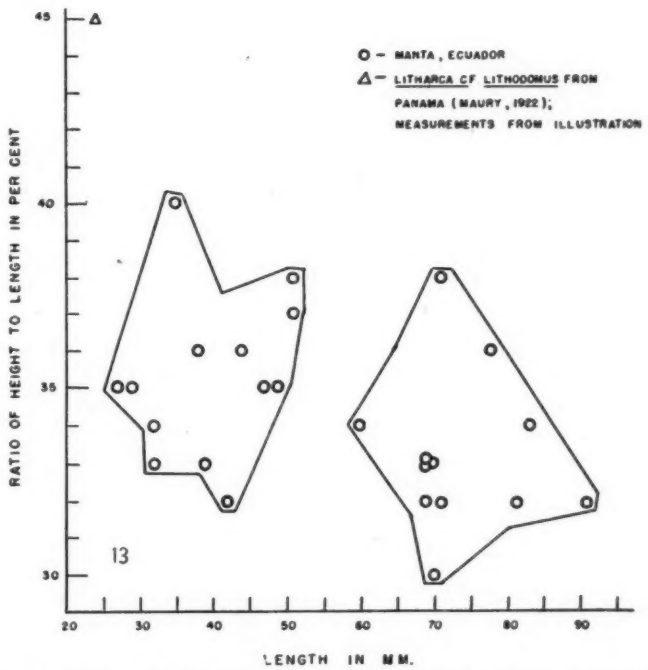
4

Litharca lithodomus (Sowerby)
Frizzell, Recent Pelecypod





FIGS. *12, 13*—Scatter diagrams showing progressive change in shape with increased size and age in 25 specimens of *Litharca lithodomus* (Sowerby) from Manta, Equador. *12*, Decrease in relative thickness; *13*, decrease in relative height.

interpretation is correct, the ligament must also have been thrust forward to a limited extent. Most of the posterior part of the original ligament, together with the posterior grooving, has been eliminated. *It is stressed that this interpretation is not solely mechanical. These changes have been subject to normal evolutionary control, and are firmly fixed in the genetic constitution of the species.*

Variation.—Figures 8 to 13, plotted from measurements of 25 specimens of *Litharca lithodomus* from Manta, Ecuador (table 2),

show a normal amount of variation. Ratios of height to length range from 30 to 40 percent, of semidiameter to length from 11 to 19 percent. Relative height decreases with increased size and age. The apparent bimodality in figure 8 is due to the lack of specimens from 52 to 60 mm. long. The distribution of relative height in right and left valves shows no distinction between the two valves. Relative thickness also shows a reduction with increasing size and age. Although the bimodality of the composite diagram (fig. 9) is somewhat exaggerated by the absence of specimens of intermediate size, the data of figure 11 show definitely the inequality between right and left valves.

Change of proportion with growth is not uncommon in the Pelecypoda but is not uniform throughout the class. Results from an unpublished study of the veneracean species *Protothaca staminea* (Conrad) (Frizzell, 1931) are introduced below for comparison with the diagrams for *Litharca lithodomus*. Year classes were determined by a count of annual growth lines. The data for these generalizations were derived from measurements of 262 specimens from Puget Sound, Washington.

Height to length ratios in relation to age: one-year class, 86 percent; two-year class, 82 percent; gradual decrease to 79 percent in five-year class; very slight increase to 80 percent in nine-year class; rapid increase to 84 percent in eleven-year class.

Diameter to length ratios in relation to age: one-year class, 55 percent; two-year class, 45 percent; regular increase to 64 percent in eleven-year class.

Ontogenetic changes in shape may be of taxonomic importance, even though growth series are not available for most species. Some data are desirable in any case, for the comparison of specimens of different ages.

The growth studies of *L. lithodomus* have been applied in an attempt to identify the specimen from Panama (Maury, 1922, pl. 1, figs. 1, 3; Reinhart, 1943, pl. 11, figs. 1–4). That shell is relatively higher than any of the topotypic series of *L. lithodomus*. Inasmuch as it was immature, and because of the characteristic decrease in relative height with growth, specific identity might be argued. To test this possible conclusion, the ratio of height to length was computed from measurements of the illustrations, and is plotted in figure 13. Its ratio of 45 percent and its length of 24 mm. place the specimen well outside the limits of the topotypic series.

Positive identification of the specimen from Panama would require an examination of material from the entire range of the genus. Numerous biometric studies of mollusks have been published, some of these showing progressive variation along coast lines and with environmental changes.[4] *L. lithodomus* may vary in a similar way. Nevertheless, until more evidence becomes available, at least the subspecific identification is questioned.

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FRESH-WATER MOLLUSKS FROM THE MORRISON FORMATION (JURASSIC) OF SUBLETTE COUNTY, WYOMING

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THIS paper deals with a single lot of silicified fresh-water mollusks from beds in Sublette County, Wyoming, that are attributed to the Morrison formation, of late Jurassic age. The locality lies west of Mill Creek below Lower Green River Lake, on the west slope of the Wind River Mountains. The collection was made by Gerald Richmond, with the assistance of W. G. Pierce and J. D. Love, to all of whom grateful acknowledgment is made.

The fauna apparently represents a new facies, for most of the genera and species have not been reported previously from the Morrison. A few of the forms, however, were originally described from Morrison deposits at other localities. There are represented 12 recognizable species of gastropods assigned to 10 genera in 6 families, and 1 pelecypod. Of these, 9 species and 3 genera are described as new. In addition, a few imperfectly preserved specimens, left unidentified for the present, indicate the presence of still other groups in the fauna.

REVIEW OF THE LITERATURE

The earliest records of fresh-water mollusks from Jurassic deposits, or beds supposed to be of Jurassic age, in North America were made by Meek and Hayden between 1858 and 1865, the first full descriptions and figures appearing in a summary discussion in the latter year. This early work noted the presence of six species, namely *Valvata? scabrida*, *Viviparus gilli*, *Planorbis veternus*, and *Unio nucalis* from the "southwest base of the Black Hills;" and *Neritella nebrascensis* and *Lioplacodes veternus* from the "head of Wind River." There was confusion, however, as to the locality of *Viviparus gilli*, and Stanton (1903, p. 196) has pointed out that it actually came from the "head of Wind River." By a slip it was ascribed by Meek and Hayden (1865, p. 107) to the Black Hills, though it occurs with *Neritella nebrascensis* and *Lioplacodes veternus*, as noted by Meek and Hayden themselves (1865, p. 115), and the original label assigns it to the "head of Wind River."

These two lots of species, occurring at different localities, seem to belong to different ages. The species from the Black Hills are now also recognized in the Morrison formation of central Colorado and southern Wyoming and seem validly assigned to the Jurassic. The species from the head of Wind River are identical with or closely related to forms from Lower Cretaceous beds that occur in the Wind River Basin near Lander, Wyoming, and that recently came to our hands through the efforts of J. D. Love.

A classic work among the earlier contributions to knowledge of the Jurassic fresh-water mollusks of the Rocky Mountain States was presented by C. A. White in 1886, in which he described six species of *Unio*, three species of *Limnaea*, and one species of *Vorticifex* in addition to his recording of *Planorbis veternus* and *Valvata scabrida* with queries. White's material was collected from the "Atlantosaurus" beds, now called the Morrison formation, 8 miles north of Canon City, Colorado, where it is directly associated with a varied dinosaurian fauna and is without doubt of Jurassic age.

In 1900 Logan published an account of mollusks from the Freeze-out Hills of Wyoming, which records three new species of *Unio*, one species of *Valvata*, and *Planorbis veternus* Meek and Hayden. We have not seen the original collection on which Logan's paper was based, and his illustrations are unusable. The species were reported to be in direct association with a Morrison dinosaurian fauna and are therefore undoubtedly of Jurassic age.

C. C. Branson published in 1935 a paper on invertebrate fossils obtained at a locality 3 miles south of Mayoworth, Wyoming. He described a new genus of unionid pelecypods

and one gastropod with two new species in each, and one new species of *Valvata*. He also recorded *Valvata scabrida*, *Lioplacodes veternus*, *Viviparus gilli*, and *Planorbis veternus*. Judged by the illustrations and a small part of his original material available to us, Branson's identifications of the previously recorded forms, probably with the exception of *Planorbis veternus*, need further confirmation, though there is no doubt of the Jurassic age of the material.

E. L. Holt in 1942 recorded a new species of unionid pelecypod from the Morrison near Fruita, Colorado, indicating that it is associated with *Vorticifex stearnsii* White. *Valvata scabrida* is recorded as occurring at a higher horizon.

COMPOSITION AND AGE OF THE FAUNA

The forms recognized in the collection described in this paper are as follows:

Valvatidae.
Valvata minuscula Yen and Reeside.
Amnicolidae.
Amnicola gilloides Yen and Reeside.
Mesocochliopa assiminoides Yen and Reeside.
Mesopyrgium pendilabium Yen and Reeside.
Ellobiidae.
Tortacella aff. *T. haldemani* (White).
Limnaeidae.
Galba ativuncula (White).
Planorbidae.
Gyraulus veternus (Meek and Hayden).
Graptophysa spiralis Yen and Reeside.
Physidae.
Physa micra Yen and Reeside.
Physa conispira Yen and Reeside.
Aplexa militaria Yen and Reeside.
Aplexa morrisonana Yen and Reeside.
Unionidae.
Unio iridoides White.

Undetermined charophyte oogonia, a few ostracodes, and a single fish vertebra are also present.

Amnicola and the planorbids are the dominant forms in the fauna. The new genera, *Mesocochliopa*, *Mesopyrgium*, and *Graptophysa*, have close relatives in the later faunal assemblages, and show that the lineages go back farther than hitherto recorded. *Tortacella* also has not been reported previously below the Cretaceous.

Almost the entire collection is of small gastropods, none exceeding 10 mm. in height. This limitation in size may be due to greater suitability of small shells for preservation, but it may also imply that the body of water in which the animals lived was shallow. The latter explanation is supported by the fact that 6 species out of 13, or about 46 percent, are air-breathing gastropods; by the abundant occurrence of individuals of the families Amnicolidae and Planorbidae, which families generally live in places covered by dense growth of vegetation, either in marshy areas or sluggish streams; and by the presence of numerous oogonia of *Chara*-like plants. The presence of so many distinct genera may well imply a sizable body of water, for such a rich fauna is not likely to arise in a small pond or stream.

As to age of the fauna, the three previously recorded species in the collection, namely *Galba ativuncula* (=*Limnaea ativuncula*), *Gyraulus veternus* (=*Planorbis veternus*), and *Unio iridoides*, were described from the Morrison formation north of Canon City, Colorado, and appear to occur consistently in Jurassic deposits. In addition, the present collection of mollusks shows a remarkable difference in elements from those in the collection noted above that was obtained from a Lower Cretaceous horizon near Lander. There is nearly nothing in common, though the geographic separation is small, probably less than 50 miles, the apparent stratigraphic position not very different, and the enclosing rocks are so similar that essentially the same ecologic environment is implied.

SYSTEMATIC DESCRIPTIONS

Family VALVATIDAE

VALVATA MINUSCULA Yen and Reeside, n. sp.

Figures 1a, b

Shell small, having an elevated spire and descending body whorl, the last one-half of which is barely attached to the penult whorl. Whorls roundly convex, slightly shouldered below the suture and rapidly increasing in size. Suture profoundly incised, the deep incision being evidently due to removal of the external layer of the shell. No sculpture visible. Aperture descending, almost circular in outline, having thin and en-

tire peristome. Umbilicus wide and open, about one-third of the shell diameter, well defined by an obtuse angulation on the basal surface of the body whorl.

Shell, altitude 2.5 mm., width 2.1 mm.; aperture diameter 1.0 mm.; number of whorls 3½.

Three species of *Valvata* have been described from Jurassic formations of North America: *Valvata gregorii* Robinson from the Morrison at Wand Terrace, 16 miles southwest of Tuba, Arizona; *Valvata leei* Logan from the "Atlantosaurus beds" (Morrison) of the Freeze-out Hills, east-central Wyoming; and *Valvata scabrida* Meek and Hayden from Jurassic beds near the southwest base of Black Hills. The present species, although represented here by a single individual, seems to be decidedly different from any of the three named forms by its smaller size, strongly convex whorls, and wider umbilicus.

U.S.N.M. 103799.

Family AMNICOLIDAE

AMNICOLA GILLOIDES Yen and Reeside, n. sp.

Figures 2a, b

Shell ovately oblong in outline, having an elevated spire and descending body whorl. The former is almost as high as the latter. Whorls rapidly increasing in size, apex small and exsert, early whorls less convex than later ones. The body whorl is slightly shouldered and bears an obtuse angulation below the well-impressed suture. Aperture pyriform, slightly oblique; peristome continuous, barely attaching to the penultimate whorl. Umbilicus narrowly perforate. Operculum moderately thick and solid, of calcareous substance, pyriform in outline, having a spiral nucleus, central in the young and subcentral in the adult specimens; spiral stage superposed and surrounded by a band of concentric increment.

	Paratype	Holotype
Altitude of shell	9.0 mm.	7.0 mm.
Width of shell	6.6 mm.	5.5 mm.
Height of aperture	4.6 mm.	3.7 mm.
Width of aperture	4.2 mm.	3.1 mm.
Number of whorls	5.0	4½

Numerous specimens representing various developmental stages are available, together with many loose opercula of various sizes. The operculum is identical in kind with that of the living fresh-water rissoid snails referred to species of the Amnicolidae, and there seems to be little doubt that the shell and operculum belong to the same species.

The species resembles in outline "*Ampullaria*" *powelli* Walcott of the Lower Cretaceous, but differs in its smaller size, higher spire, and more strongly convex whorls.

Holotype, U.S.N.M. 103800; paratypes, U.S.N.M. 103801.

MESOCOCHLIOPA Yen and Reeside, n. gen.

Shell umbilicate, small, having an elevated spire and moderately dilated body whorl. Whorls convex, gradually increasing in size, and rounded along the periphery. Aperture ovate and gently descending.

Genotype, *Mesocochliopa assiminoides* Yen and Reeside.

The genus under consideration recalls *Cochliopa* Stimpson, described from North America. The present available data do not permit us now to establish definitely its relationship with that genus, represented so far by living species only. However, the morphological features seem to indicate relationship.

MESOCOCHLIOPA ASSIMINOIDES Yen and Reeside, n. sp.

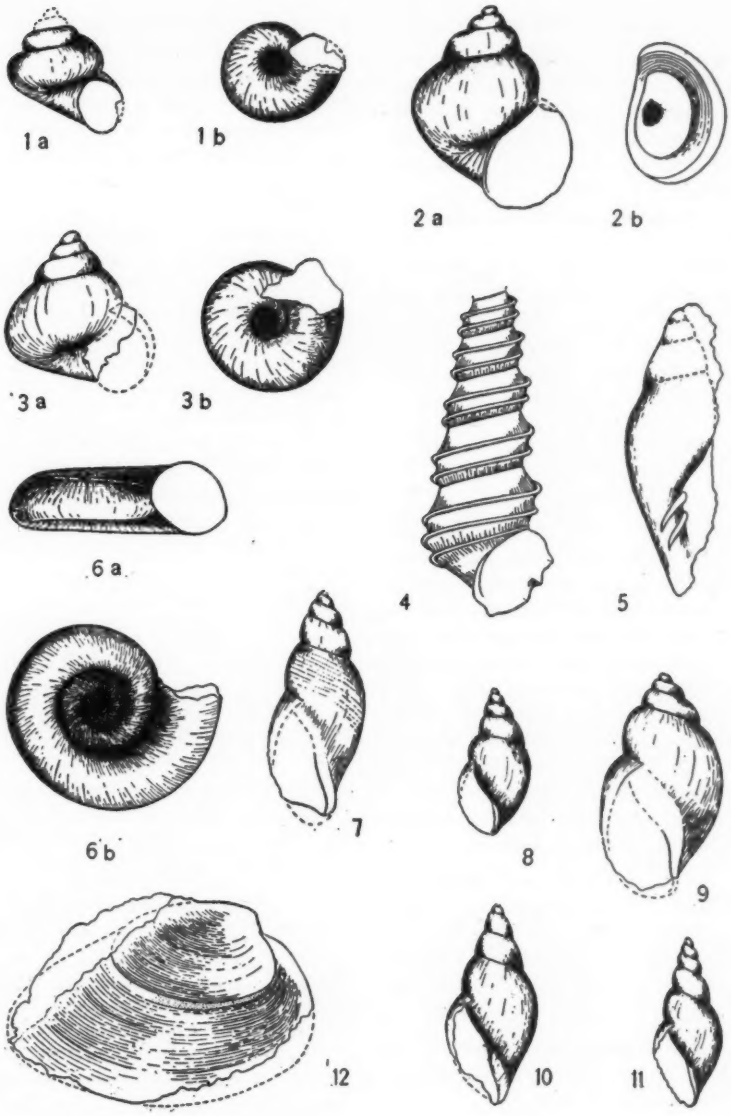
Figures 3a, b

Shell short and broad, small, having a conical spire about as high as the body whorl. Whorls gently convex, increasing gradually in size. No sculpture visible; suture well impressed. Body whorl descending, gently dilated, roundly convex at the periphery as well as on basal surface; aperture ovate. Umbilicus exposed and deep, about one-fourth the diameter of the shell in width. Operculum unknown.

Altitude of shell 2.5 mm.; width 2.0 mm.; diameter of umbilicus 0.5 mm.; number of whorls 4½.

The species is characterized by its small size, broadly conical outline, and widely exposed umbilicus. Two examples of younger stages in the collection are of smaller size, with a little over one whorl less.

Holotype, U.S.N.M. 103802; paratypes, U.S.N.M. 103803.



EXPLANATION OF FIGURES 1–12

FIGS. *1a, b—Valvata minuscula* Yen and Reeside. ×8. (p. 53)
2a, b—Amnicola gilloides Yen and Reeside. ×4. (p. 54)
3a, b—Mesocochliopa assiminoides Yen and Reeside, ×8. (p. 54)
4—Mesopyrgium pendilabium Yen and Reeside. ×8. (p. 56)
5—Tortacella aff. *T. haldemani* (White). ×8. (p. 56)
6a, b—Gyraulus veternus (Meek and Hayden). ×8. (p. 56)
7—Graptophysa spiralis Yen and Reeside. ×8. (p. 57)
8—Physa micra Yen and Reeside. ×8. (p. 57)
9—Physa conispira Yen and Reeside. ×4. (p. 57)
10—Aplexa militaria Yen and Reeside. ×4. (p. 57)
11—Aplexia morrisonana Yen and Reeside. ×4. (p. 58)
12—Unio iridoides White. ×4. (p. 58)

MESOPYRGIUM Yen and Reeside, n. gen.

Shell imperforate, small, with highly turrited spire. Apical whorls smooth, subsequent whorls bearing spiral carinae. Aperture descending, anteriorly notched. Peristome thin, expanded at outer margin. Columella slightly reflected.

Genotype, *Mesopyrgium pendilabium* Yen and Reeside.

The size and general shape of the shell recall some forms of *Pyrgula* Christofori and Jan, but the new genus differs in its expanded outer lip and the presence of an anterior notch, which are features generally borne by species of cerithioid snails.

MESOPYRGIUM PENDILABIUM Yen and Reeside, n. sp.
Figure 4

Shell imperforate, small, slender, with highly turrited spire and descending body whorl. Whorls increasing moderately rapidly in size, first two smooth and roundly convex, subsequent whorls bearing two spiral carinae on flatly concave surface with a basal carina appearing below periphery of the body whorl. Suture shallow but traceable. Aperture descending, slightly oblique, and of ovately polyangulated form. Peristome thin, expanded at outer margin, a notch present at anterior end. Columellar margin slightly reflected; parietal wall well defined.

	Paratype	Holotype
Altitude of shell	5.1 mm.	5.6 mm.
Width of shell	2.2 mm.	2.2 mm.
Height of aperture	1.0 mm.	1.0 mm.
Width of aperture	1.0 mm.	1.0 mm.
Number of whorls	7.3	8.0

This species is readily recognized by its small size, high spire, heavy spiral carinae, and expanded margin of outer lip.

Holotype, U.S.N.M. 103804; paratypes, U.S.N.M. 103805.

Family ELLOBIIDAE

TORTACELLA aff. T. HALDEMANI (White)

Acella haldemani WHITE, 1878. U. S. Geol. and Geog. Survey Terr. Bull. 4, pt. 3, p. 714.
Tortacella haldemani WHITE, 1895, U. S. Geol. Survey Bull. 128, p. 44, pl. 5, figs. 8, 9.
Tortacella wyomingensis HENDERSON, 1935, Geol. Soc. America Spec. Papers no. 3, p. 234.

A single imperfect specimen resembles *Tortacella haldemani* (White) of the Upper Cretaceous Bear River formation. This shell is small and slender, with weakly convex whorls that bear distinct but fine costulate growth lines and a narrow aperture with two oblique plicae on its columellar margin. The preserved part of the shell is 5.2 mm. in altitude, 2.0 mm. in width, and has about 3 whorls.

Change of the name *T. haldemani* to *T. wyomingensis* by Henderson in 1920 (Nautilus 33, p. 108), reaffirmed in 1935, does not seem to be necessary. The original name was only a secondary homonym of *Limnaea haldemani* Deshayes, 1867, and, as long as *Acella* is recognized as a valid genus, no change is needed.

Tortacella may possibly be a synonym of *Zaptychius* Walcott, of the Lower Cretaceous. However, the problem cannot be settled for the present, as the holotype specimen of Walcott's genotype is not well preserved.

U.S.N.M. 103806.

Family LIMNAEIDAE

GALBA ATIVUNCULA (White)

Limnaea ativuncula WHITE, 1886, U. S. Geol. Survey Bull. 29, p. 20, pl. 4, fig. 11.
Galba ativuncula BAKER, 1911, Chicago Academy Sci. Spec. Pub. no. 3, p. 87, pl. 16, fig. 2.

Two imperfect specimens agree well with the smaller specimen contained in the type lot of this species (U.S.N.M. 20054).

U.S.N.M. 103807.

Family PLANORBIDAE

GYRAULUS VETERNUS (Meek and Hayden)
Figures 6a, b

Planorbis vetternus MEEK and HAYDEN, 1860, Acad. Nat. Sci., Philadelphia, Proc., vol. 12, p. 418; 1865, Smithsonian Contr. Knowledge, vol. 14, no. 172, p. 107, pl. 4, fig. 1.

Over a hundred specimens, representing various developmental stages, are available. These seem to be identical with this species as originally described from the Black Hills area. It is characterized by its small size and rapidly increasing whorls. A mature individual measures 1.0 mm. in altitude, 2.2 mm. in width, and has $3\frac{1}{2}$ whorls.

U.S.N.M. 103808.

GRAPTOPHYSA Yen and Reeside, n. gen.

Shell sinistral, imperforate, narrowly oblong in outline, having rapidly increasing whorls, which are separated by an incised

suture. Sculpture consisting of both growth lines and incised spiral lines. Aperture narrowly ovate in form, with simple and thin peristomal margin and well-twisted columella.

Genotype, *Graptophysa spiralis* Yen and Reeside.

The genus consists of forms of *Physa*-like snails that bear both growth lines and spiral sculpture and have incised sutures. It recalls some species of *Camptoceras* Benson, found in the Recent fauna, and *Pseudophysa* Yen, described from Pliocene fresh-water beds of Yunnan, China.

GRAPTOPHYSA SPIRALIS Yen and Reeside, n. sp.
Figure 7

Shell sinistral, fusiform, imperforate, small, having the spire about as high as body whorl. Whorls rapidly increasing in size, gently convex on exposed surface, and separated by an incised suture. Sculpture consists of growth striae and spiral lines, which are well shown on better-preserved individuals. Aperture of narrowly ovate form, simple and thin at outer lip margin, attenuated at parietal wall and well twisted toward the columella.

	Holotype	Paratype
Altitude of shell	3.2 mm.	4.1 mm.
Width of shell	1.4 mm.	2.0 mm.
Height of aperture	1.4 mm.	2.0 mm.
Width of aperture	0.5 mm.	1.0 mm.
Number of whorls	4.0	4.5

The younger forms are more ovate in outline, and the whorls increase more rapidly in length than width, most of the examples appear to be smooth on the exposed surface of the whorls, apparently owing to poor state of preservation.

Holotype, U.S.N.M. 103809; paratypes, U.S.N.M. 103810.

Family PHYSIDAE

PHYSA MICRA Yen and Reeside, n. sp.
Figure 8

Shell sinistral, ovately globose in outline, with a short but elevated spire and dilated body whorl; spire about one-third of the entire height of the shell. Whorls rapidly increasing in size, well-rounded on exposed surface, slightly shouldered below the suture. Body whorl ventricose, roundly convex along periphery. Aperture ovate in outline, having thin outer lip and parietal wall, weakly twisted columella with slightly reflected margin. Umbilicus narrowly perforate.

Altitude of shell 3.5 mm.; width of shell 2.0 mm.; height of aperture 2.3 mm.; width of aperture 0.10 mm.; number of whrols 5.3.

The species approaches in size and general outline *Physa walcotti* Yen and Reeside[1] of the Lower Cretaceous. However, it differs by its more strongly convex whorls, which are well shouldered.

Holotype, U.S.N.M. 103811; paratypes, U.S.N.M. 103812.

PHYSA CONISPIRA Yen and Reeside
Figure 9

Shell sinistral, broadly fusiform, small. Spire conical, a little higher than the body whorl. Whorls increasing rapidly, with exposed surface gently convex. Sutures well impressed. Body whorl moderately dilated but somewhat reduced at the base. Aperture narrowly ovate in outline; outer lip and parietal margin thin; columella slightly reflected. Umbilicus very narrowly perforate.

Altitude of shell 5.0 mm.; width of shell 2.8 mm.; height of aperture 2.4 mm.; width of aperture 1.4 mm.; number of whorls 6.0

The species differs from *Physa walcotti* by its broadly fusiform outline, more convex whorls, and higher spire. Most other species of *Physa* from various Cretaceous horizons in North America are much larger.

Holotype, U.S.N.M. 103813; paratypes, U.S.N.M. 103814.

APLEXA MILITARIA Yen and Reeside, n. sp.
Figure 10

Shell sinistral, subfusiform in outline, and small. Spire conically elevated, almost equal in height to the body whorl. Whorls rapidly increasing in size, scarcely convex, and bearing distinct axial lines and fine growth striae on the interspaces. Suture superficially impressed. Body whorl narrowly dilated, reduced at base. Aperture subpyriform in outline, outer lip thin and simple, parietal

[1] The name *Physa prisca* Walcott (1883, p. 808) is preoccupied by *Physa prisca* Noulet (1854, p. 12). *P. prisca* Walcott is here renamed *Physa walcotti*.

wall thinly spreading, not well defined, and columella slightly reflected to form an almost imperforate umbilicus.

Altitude of shell 6.5 mm.; width of shell 3.0 mm.; height of aperture 3.3 mm.; width of aperture 1.3 mm.; number of whorls 5.0.

This species and the following are provisionally assigned to the genus *Aplexa*, because of the scarcely convex whorls and high spire. They are, however, much smaller than most species of that genus.

Holotype, U.S.N.M. 103815; paratypes, U.S.N.M. 103816.

APLEXA MORRISONANA Yen and Reeside n. sp.
Figure 11

Shell sinistral, subfusiform, small, having gradually tapering spire and narrowly dilated body whorl, the former higher than the latter. Whorls increasing in size with moderate rapidity; gently convex. Suture well impressed. Aperture subpyriform in outline, outer lip and parietal wall thin and simple. Columella twisted in the lower part and slightly reflected at the base. Umbilicus almost imperforate.

	Holotype	Paratype
Altitude of shell	5.8 mm.	7.0 mm.
Width of shell	2.3 mm.	3.0 mm.
Height of aperture	2.5 mm.	—
Width of aperture	1.0 mm.	—
Number of whorls	5½	6½

This species is characterized by its slender outline, highly turrited spire and narrowly dilated body whorl. It has a higher spire and narrower width of body whorl than the preceding species, *Aplexa militaria*. However, it is much smaller than most of the other known species of the genus.

Holotype, U.S.N.M. 103817; paratypes, U.S.N.M. 103818.

Family UNIONIDAE
UNIO IRIDOIDES White
Figure 12

Unio iridoides WHITE, 1886, U. S. Geol. Survey Bull. 29, p. 17, pl. 2, figs. 3, 4.

Two specimens, much smaller than the types, seem to be the young form of this species. They agree in character sufficiently well to justify use of the name.

Plesiotype, U.S.N.M. 103819.

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JOURNAL OF PALEONTOLOGY, VOL. 20, NO. 1, PP. 59–61, 3 TEXT FIGS., JANUARY 1946

STICHOCASSIDULINA, A NEW GENUS OF FORAMINIFERA FROM NORTHWESTERN PERU

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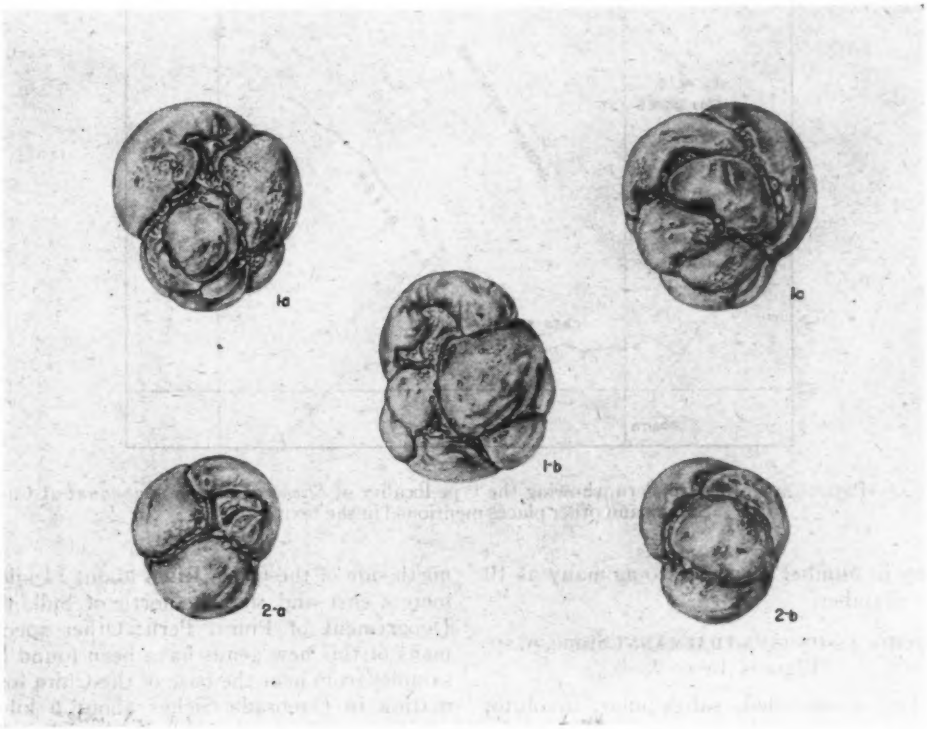
International Petroleum Company, Ltd., Negritos, Peru

THE Chira formation of northwestern Peru is so named because of the numerous outcrops of this shale along the Chira River. Lithologically it is predominately composed of light to maroon-colored shale with a few white bentonite beds and some thin sandstone beds.

Family CASSIDULINIDAE
Subfamily CASSIDULININAE
Genus STICHOCASSIDULINA Stone, n. gen.

Genotype, *Stichocassidulina thalmanni* Stone, n. sp.



FIGS. *1*, *2*—*Stichocassidulina thalmanni* Stone, n. sp., ×30. *1*, Holotype; *a*, ventral view, showing large aperture with toothlike plate and supplementary apertures along the sutures; *b*, side view, showing arrangement of chambers; *c*, dorsal view, showing alternating biserial arrangement of the chambers and conspicuous supplementary apertures along the sutures. *2*, Paratype, immature test; *a*, ventral view, showing numerous supplementary apertures; *b*, dorsal view.

Near the base of the Chira formation an unusual foraminifer has been found which appears to belong to a genus different from any hitherto described. For this new form the genus *Stichocassidulina* is here proposed.

This genus very closely resembles *Cassidulina* in having a close-coiled biserial arrangement of chambers. It differs from *Cassidulina* in having numerous small supplementary apertures in addition to the one

large aperture located in the face of the last-formed chamber. The main aperture is loop-shaped, large, and almost entirely covered by a flat toothlike plate. The supplementary apertures are small arcuate openings along the sutures of the test. These openings are in no way restricted to the sutures of the last-formed chamber but occur on all the sutures of the test. They may vary in number from one to as many as 10 per chamber.

STICHOCASSIDULINA THALMANNI Stone, n. sp.
Figures 1a–c, 2a–b

Test close-coiled, subglobular, involute; chambers alternating on the two sides of the periphery, smooth; wall calcareous, finely perforate; apertures of two types, one a large loop-shaped elongate opening in the face of the last-formed chamber almost entirely covered by a toothlike plate, the other apertures are numerous small arcuate openings situated along the sutures of the test. Dimensions of genotype: height, 0.63 mm.; breadth, 0.49 mm.; thickness, 0.50 mm.

The holotype (559823) and paratype (559822) specimens have been deposited in the type collection of the United States National Museum. Duplicate material has been placed in the collection of the Cushman Laboratory for Foraminiferal Research and the American Museum of Natural History.

The type locality of *Stichocassidulina thalmanni* is in an outcrop of the Chira formation on the east side of the Talara-Sullana road at Casa Saman. This spot is on the north side of the Chira River about 14 kilometers east and slightly north of Sullana, Department of Piura, Peru. Other specimens of this new genus have been found in samples from near the base of the Chira formation in Quebrada Siches about 6 kilometers south of El Alto, Department of Piura, Peru. A few specimens have also been found in International Petroleum Company well no. 3349 in the Lagunitos District at a depth of 1,100 feet. This genus likewise occurs in other wells of this district. Figure 3 shows the type locality and other places mentioned above.

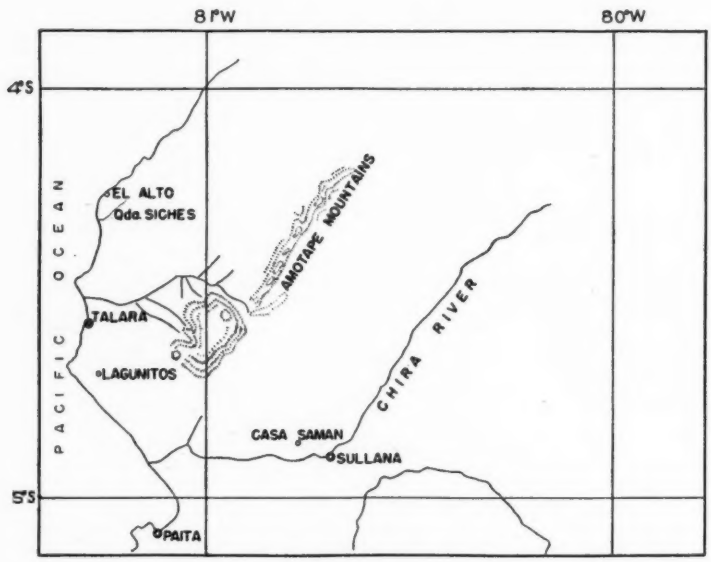


FIG. 3—Part of northwestern Peru, showing the type locality of *Stichocassidulina thalmanni* at Casa Saman and other places mentioned in the text.

The Chira formation is considered to be uppermost Eocene in age as evinced by the occurrence of *Hantkenina* and its faunal similarities with beds of upper Eocene age

in Ecuador. According to H. E. Thalmann (1942) the genus *Hantkenina* is restricted to sediments of upper Eocene age. In well no. 3349 mentioned above, specimens of *Hantkenina* were found at a depth of 500 feet and thus overlie *Stichocassidulina*.

The author wishes to express his thanks to Dr. H. E. Thalmann for his kind assistance, to Dr. J. A. Cushman, and to the Directors of the International Petroleum Company, Ltd., through whose permission the publication of this paper has been possible.*

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JOURNAL OF PALEONTOLOGY, VOL. 20, NO. 1, PP. 62–67, PL. 11, 1 TEXT FIG., JANUARY 1946

A NEW CROCODILIAN FROM THE EOCENE OF UTAH

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ONE of the important discoveries of the 1938 expedition of the Smithsonian Institution to the Uinta Basin, Utah, was the well-preserved skull and jaws of a small alligatoroid reptile representing an undescribed genus and species of the Crocodilia. If this assignment is correct, it marks the first recognition of this group in the Uinta fauna, as well as its first discovery in the state of Utah. The name *Procaimanoidea utahensis* is proposed for its reception.

The illustrations were prepared by Mrs. Aime M. Awl.

Order CROCODILIA
Family ALLIGATORIDAE
Plate 11, figures 1–4; text figure 1
PROCAIMANOIDEA UTAHENSIS Gilmore, n. gen., n. sp.

Type, U.S.N.M. no. 15996, consisting of a slightly incomplete skull, right ramus and both ends of the left; distal ends of the left tibia and fibula, tarsus, and four metatarsals lacking their distal ends. Collected by G. F. Sternberg, July 1, 1938.

Paratype, U.S.N.M. no. 15997, consisting of the right ramus lacking the posterior end, and a fragment of a maxillary. Collected by G. F. Sternberg, July 1, 1938.

Type locality, "Myton Pocket," Uinta Basin, Uinta County, Utah.

Horizon, Myton member, Uinta C, Eocene.

Diagnosis: Alligatoroid of small size. Skull and jaws narrow, strongly triangular in profile, with alligatoroid bite. Interorbital region flat. Nasals extending into but not dividing external nares. Internal nares placed relatively forward. Snout angulated, presenting three distinct planes. Frontals narrow between orbits. Lacrimals not (?) in contact with nasals. Postdental part of mandible subequal in length with dental portion. Splenial participating little if at all in the symphysis. Eighteen upper and nineteen lower teeth. All lower teeth biting within the upper; fourth and thirteenth enlarged and received in pits in the palate. Crowns of all except posterior four subspatulate, with sharp edges fore and aft; four posterior teeth blunt, low-crowned, transversely compressed.

The type skull is in excellent preservation, except for the loss of the left maxillary, lacrimal, prefrontal, and a few of the teeth. That this specimen is adult appears to be indicated by the complete coalescence of many of the sutures. There is slight distortion from crushing, but all in all the shape and proportions of the type skull are very nearly that of a recent cranium. This is a rare occurrence among the fossil Crocodilia, for they are usually found flattened. A side view (see pl. 11, fig. 4) with the articulated ramus in position gives a correct idea of the natural profile. Viewed from above the skull is relatively subacuminate in outline, narrow throughout its length, with a rounded snout. The cranial table is flat, slightly longer than broad, and perforated with long ovate supratemporal fossae. The space beteeen them is relatively broad. The superior surface of the snout is flat and slopes strongly downward from the midfrontal region. In cross section the skull anterior to the orbits is angulated, presenting three distinct planes as in the modern *Caiman*. No constriction at the lateral border of the snout along the line of the maxillo-premaxillary suture. The central half of the snout is flat except for a slight median depression. In outline and several other particulars *C. utahensis* has its nearest resemblances to *Caiman trigonatus* among extant Crocodilidae.

BONES OF THE SKULL

The *parietal* is perfectly flat and lacks the uprolled edges usually present in the *Allognathosuchus* skulls from the Wasatch. The sculpturing of the surfaces also lacks the definition of those crania. The posterior border of the parietal forms about one-third of

[1] Died September 27, 1945. Proofs have been read by the editors.

this edge of the cranial table, which is strongly concave from side to side. At the center it has a greatest length of 21 mm.; the narrowest part of the infrafenestral plate is 9 mm.

The extreme narrowness of the *frontals* between the center of the orbits is one of the outstanding characters distinguishing this species. The least transverse measurement is about half that of an *Allognathosuchus heterodon* skull of equivalent size. It also lacks the uprolled edges of the nasals of the last mentioned species. The suture with the parietal is a broad curve from side to side, with the convexity directed posteriorly. The frontal (see fig. 1A) does not participate in the boundary of the supratemporal fossa. At about midlength the frontal bends downward, passing smoothly into the moderately steep slope of the nasals. The anterior ends of the frontals project forward between the prefrontals as a narrow tongue of bone with parallel sides that meet the nasals on the median line. The frontals have a greatest length of 40 mm., and a least width between the orbits of 7 mm.

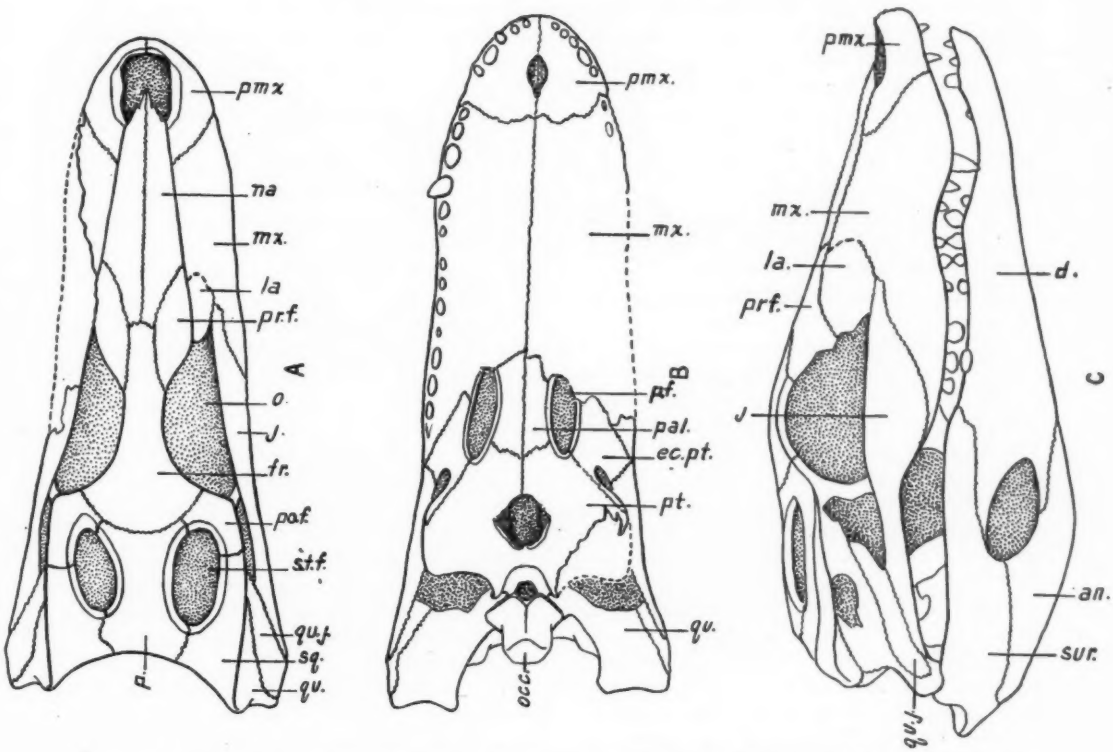

FIG. 1—*Procaimanoidea utahensis* Gilmore, n. gen., n. sp. Type (U.S.N.M. 15996), skull and lower jaws, $\times\frac{3}{4}$. Drawing indicates separate elements so far as they can be determined. *A*, superior view; *B*, inferior view; *C*, lateral view; *an*, angular; *b.sp.*, basisphenoid; *d*, dentary; *ec.pt.*, ectopterygoid; *fr*, frontal; *j*, jugal; *la*, lacrimal; *mx*, maxillary; *na*, nasal, *o*, orbit; *oc.c*, occipital condyle; *p*, parietal; *pal*, palatine; *p.f*, palatine fenestra; *pmx*, premaxillary; *po.f*, postfrontal; *pr.f*, prefrontal; *pt*, pterygoid; *qu*, quadrate; *qu.j*, quadrato jugal; *sq*, squamosal; *s.t.f*, supratemporal fossa; *sur*, surangular.

The *nasal* bones are relatively short. On the median line they measure 42 mm. in length, which is considerably less than one-half the total length of the skull. Viewed from above, the nasals with the prefrontals present a flat surface that breaks off angularly following the suture line with the premaxillary and maxillary. The posterior half

of the nasals are shallowly concave on the dorsal surface along the median line. The anterior ends of the nasals that extend into the narial aperture narrow rapidly to a sharp point that terminates at about midlength of the narial opening.

The *prefrontals* are of moderate size with acuminate ends. The sharp anterior end is wedged in between the frontal and nasal on the inner, and the lacrimal and maxillary on the outer side. The tapering posterior end forms the anterior-upper boundary of the orbit, terminating forward of the middle of that opening. The right prefrontal has a greatest length of 24 mm.

The *postfrontal* is slightly longer than wide but otherwise there is nothing distinctive that requires special mention.

The left *lacrimal* is entirely missing, but the right element is present as shown in figure 1C, although complete coalescence of part of its anterior sutural contact with the maxillary leaves some uncertainty as to its precise outline and extent. As interpreted (see fig. 1C) it is exceedingly *Alligator*-like in not being in contact with the nasal, but this important feature needs confirmation from other sources before acceptance as an established fact. The lacrimal on the posterior border is perforated by the usual lacrimal foramen, which is not visible from a lateral view.

The *premaxillaries* are relatively long and narrow, with regularly rounded anterior ends. The posterior processes that wedge in between the maxillaries and the nasals are short and stout, with acute posterior ends. On the palate the suture with the maxillaries lies in front of the alveoli for the second maxillary tooth. The premaxillo-nasal sutures converge in the anterior direction.

The right *maxillary* is relatively short and broad. In the articulated skull its outer surface stands at an angle of about 45° to the horizontal, and that plane is maintained up to its contact with the nasal. The length of this suture is relatively much shorter than in the Florida alligator. Its union with the lacrimal is not to be clearly observed in the present specimen. As in other crocodilians the maxillaries form most of the palate. The bone is missing in the area where the palatines and maxillaries form their junction, so that there is no clue as to the anterior extent of the palatines. The suture with the ectopterygoid is plainly shown on the right side; its forward termination with the maxillary ends opposite the second maxillary tooth enumerated from the posterior end. All 13 maxillary teeth appear to have separate alveoli.

The *jugal* is relatively slender with a pointed anterior end that terminates anteriorly slightly in front of the orbital border. Its external surface is fully sculptured, otherwise it displays no distinctive peculiarities.

The *quadratojugal* does not appear to have developed any sharp protuberances extending into the lateral temporal fenestra, being more like the alligator than the true crocodiles in this respect.

The *quadrates* differ in no essential particulars from other crocodilians.

The *supraoccipital*, *exoccipitals*, *basioccipital*, and *basisphenoid* are completely coossified with one another, and thus their boundaries can no longer be determined. Since this region of the skull is essentially like most other crocodilians, there seems no need for a detailed description.

The *palatines* are relatively narrow, measuring 8 mm. at their narrowest part between the palatine fenestra. The anterior ends of both are missing. The palatine-pterygoid suture runs straight across about as in *Alligator mississippiensis*.

The right *pterygoid* is complete and free from distortion; its counterpart of the opposite side lacks about half of its downward winglike portion. The posterior narial opening is placed farther forward between the pterygoids than in either *Crocodilus* or *Alligator*, and the slot behind this orifice leading up to the base of the basipterygoid is narrower transversely than in either of those

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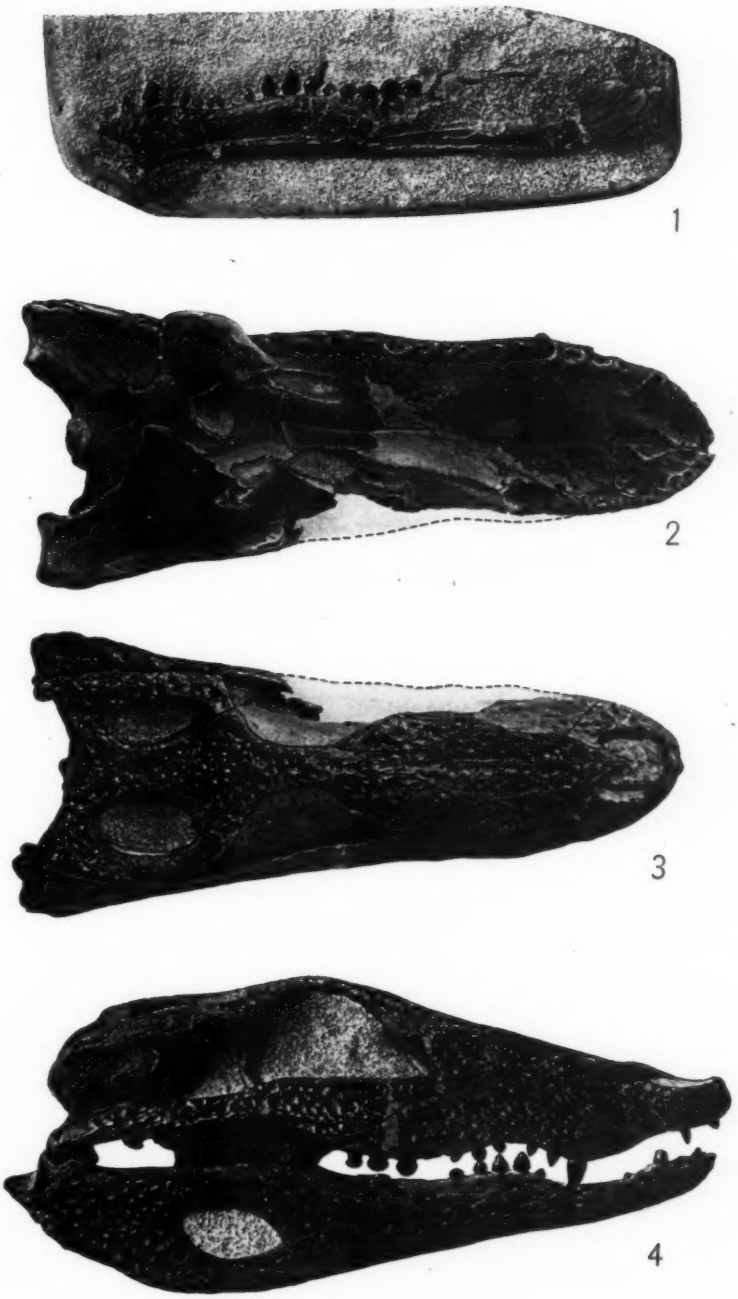
EXPLANATION OF PLATE 11

FIGS. *1–4*—*Procaimanoidea utahensis* Gilmore, n. sp., ×¾±. *1*, Paratype, no. 15997 U.S.N.M., incomplete right mandible, internal view. *2*, Type, no. 15996 U.S.N.M., skull, palatal view. *3*, The same, dorsal view. *4*, The same with mandible, lateral view. (p. 62)



Procaimanoidea utahensis Gilmore, n. sp.
Gilmore, Eocene Crocodilian

genera. The forward position of the narial opening among the extinct forms is closely approximated by both *Allognathosuchus* and the South American *Eocaiman*. There is no evidence of a median longitudinal division of this orifice.

The *ectopterygoid* forward extension where it joins the inner posterior end of the maxillary terminates anteriorly opposite the middle of the next to the last tooth, as in *Alligator*.

Fenestra of the skull. The *supratemporal fenestra* have not been cleaned of matrix for their full depth, but slightly below the level of the cranial table (see pl. 11, fig. 2) they are elongate oval in outline. This was first regarded as a distinctive character of this species, but it must be used with reservations as Mook (1921b) points out in *Crocodilus intermedius* it is a "character indicating youth." The right fenestra is slightly larger than the left, but this, in part, is due to incorrect restoration of the broken bar on the outside of the cranial table. The fenestra are slightly oblique to the longitudinal axis of the skull.

The *orbit* is large and looks more outward than upward. The posterior and postero-internal borders are broadly rounded, with a nearly straight lower border. The anterior termination is a blunt point that ends above the ninth maxillary tooth. According to Mook (1921b) this fact also indicates an immature specimen. Several skulls of *Allognathosuchus heterodon* in the National Museum collections, however, show the same relationship of anterior orbital termination and posterior teeth. In *Caimanoidea visheri* the anterior border of the orbit is also above the ninth tooth.

The *external nares* are subquadrangular in outline, slightly longer than wide. The pointed anterior ends of the nasals protrude well forward into the narial opening dividing the posterior portion into two halves. There is no indication of a backwardly directed premaxillary process. The posterior border is slightly elevated; there is a distinct raised anterior border, one of the features distinguishing it from *Caimanoidea*.

The *premaxillary foramen* is relatively large, with acute anterior and posterior ends. On the median line it occupies about one-half the space between the tip of the snout and the premaxillo-maxillary suture.

The *palatine fenestrae* are relatively small and narrow. The inner border of the right aperture is bounded almost wholly by the palatine; the outer by the ectopterygoid and maxillary. The pterygoid appears to form the posterior boundary, but the broken condition of the bone surface at this point makes it slightly uncertain. The anterior end appears to be acute, though the bone is missing from this part of the palate, and thus leaves one in doubt as to its full anterior extent.

The *internal narial foramen* in this specimen shows no indication of there having been a median septum of bone, as is present in *Alligator* and in many living species of crocodilians. The posterior half of this opening is surrounded by a semicircular ridge that extends prominently downward from the general surface level. This aperture lies well forward in the center between the postero-external flanges of the pterygoids, as in *Eocaiman*.

Mandible. The lower jaws in the type are represented by the nearly complete right ramus and the anterior and posterior ends of the left. The paratype (U.S.N.M. 15997, pl. 11, fig. 1) consists of about three-fourths of the right ramus, containing a nearly complete set of teeth, thus from a study of both specimens practically a complete knowledge of the lower mandible is obtained. The jaw as a whole is slender and relatively straight, lacking the strong vertical curve of the lower border as in the type of *Allognathosuchus polyodon*. The symphysial portion is shallow vertically and of moderate breadth. The angle of the symphysial articulation indicates that the two rami were not widely divergent, thus conforming to the narrow snout of the skull.

The splenial participates little if at all in the symphysis. The anterior end of the jaw is but slightly elevated; posterior to the fifth tooth the superior border descends in a gentle curve, rising again in a reverse curve to an enlargement which lodges the largest tooth (thirteenth) of the lower series; posterior to this tooth the surface again forms a gentle curve to the end of the dental row. The upper border posterior to the last tooth rises regularly to the surangular border but not with the abruptness of the type jaw of *A. polyodon*, a character considered by Mook

(1921a) to be one of the distinctive features of that species.

The mandibular foramen is relatively small as compared with an *Alligator mississippiensis* jaw of the same size. The symphysial surface extends posteriorly to a point about opposite the fourth tooth.

The anterior external surfaces are ornamented by numerous small pits; on the extreme ventral surface these pits become elongate. The greater part of the external surface of the angular and surangular bones is sculptured by coarse, deep, irregularly placed pitting. The area posterior to this coarse pitting on the extreme outer surface of the angular and articular is smooth. Measurements of the mandible will be found in the table.

Dentition. The dental formula of *Procaimanoidea utahensis* appears to be premaxillary teeth 5, maxillary 13, and dentary 19, the same as in *Caimanoidea* and the living *Alligator sinense*. The distribution of large and small teeth, with the presence of flat, blunt-crowned ones in the posterior ends of both upper and lower series is quite similar to the conditions found in *Allognathosuchus*.

In the type Utah skull now before me, the following teeth are preserved: on the right side, root of the second, third (lacking the tip), and fifth; on the left side, the third (lacking the tip), and complete fifth, all of the premaxillaries. In the right maxillary enumerating from the posterior end there is a series of 10 complete teeth. The fourth from the last is a germ tooth just emerging from the alveolus. In front of the largest tooth there is evidence of three additional teeth, thus making 13 in the complete maxillary series. The teeth are closely and evenly spaced except for short diastema between the fifth premaxillary tooth and the first of the maxillary, and again between the sixth and seventh maxillary teeth. When the jaws are closed, these gaps are opposite the pits in the palate which receive the two largest teeth of the lower mandible, the fourth and thirteenth.

In the maxillary series, judging from the size of the alveoli, the fourth tooth is largest, the third being second in size. The fifth, sixth, seventh, eighth and ninth maxillary teeth are small with pointed crowns. The tenth, a germ tooth, is not sufficiently erupted to show the form of its crown. The last three teeth have blunt, short crowns, which are much compressed transversely, not globose as in *Allognathosuchus*. The thirteenth or last tooth is smaller than the eleventh. On the outer side of all the tooth crowns their surfaces are sculptured by fine parallel grooves and ridges that extend from the base of the crown nearly to the top, fading out before reaching the tips. This sculpturing is much less pronounced on the inner sides of the teeth, except on the blunt crowns where the definition is subequal on the two sides. The lines of the sculpturing show a tendency to radiate from the crown top on these posterior teeth.

The lower dentition is best preserved in the paratype (U.S.N.M. 15997, see pl. 11, fig. 1). Counting from the posterior end, in this specimen there are 17 consecutive teeth, with alveoli at the anterior end for two more. Thus, there were certainly 19 teeth in the complete mandibular series. The large fourth tooth in the symphysial region is followed by seven small teeth, instead of eight as in the type of *A. polyodon*. All of these are missing in the type. Posterior to this group of seven small teeth are three large teeth, the middle one in both jaws being the largest of the lower series. They occupy the summit of the jaw elevation at this point. The four posterior teeth of the paratype are all of the short, blunt-crown variety as in the upper. The total length of the dental series is 75.5 mm., lower 76 mm. None of the teeth in either upper or lower series are conical; excepting the four posterior teeth, all of the other crowns are subspatulate with sharp carinae fore and aft. The large fourth mandibular tooth fits into a pit on the internal side between the fifth premaxillary and the first maxillary tooth; the thirteenth mandibular tooth is received in a pit on the internal side between the sixth and seventh maxillary teeth.

MEASUREMENTS OF THE SKULL AND JAWS, No. 15996, U. S. N. M.

	Mm.
Length, end of quadrate to tip of snout	127.0
Length, occipital condyle to tip of snout	117.0
Breadth, across quadrates	52.0
Breadth, posterior border of cranial table	35.0

	Mm.
Breadth, premaxillary-maxillary suture	27.0
Breadth, at fourth maxillary tooth	24.0
Breadth, plate, between supratemporal fenestra	9.7
Breadth of interorbital plate	7.0
Length of tooth row, upper	75.0
Length of orbit	33.0
Length of external narial aperture	13.0
Length of premaxillary foramen	7.0
Greatest length of mandible (as preserved)	132.0
Greatest depth	23.0
Greatest depth at symphyses	5.5
Greatest width across symphysis	13.5
Length of lower tooth row	66.0

Relationships. Procaimanoidea utahensis with its alligatorid bite, lack of constriction at the premaxillo-maxillary suture, lacrimal not (?) in contact with the nasal, dental formula (18 teeth above, 19 below), with low-crowned, blunt posterior teeth, indicates that its affinities lie in the alligatorid group of the Crocodilia. In North America this group is best represented by *Allognathosuchus, Caimanoidea* and *Alligator*. The nearest affinities of *Procaimanoidea* appear to be with the Oligocene *Caimanoidea*, a conclusion reached on the basis of the subequal length of the dental and postdental parts of the mandible, like number of teeth in upper and lower dentitions, and similar uncrested preorbital region. These features effectually set these genera off from *Allognathosuchus* and *Alligator*, with which both have other characters in common.

Mehl (1916) has suggested that *Caimanoidea* is close to the ancestry of *Caiman* but collaterally related. The subacuminate outline of the skull of *Procaimanoidea*, with angulated snout into three distinct planes in front of the orbits, are *Caiman* features already accomplished in the Eocene, and appear to give support to Simpson's (1933, p. 7) contention that the Oligocene "*Caimanoidea* is not particularly related to *Caiman* but is nearer the *Alligator* phylum." In any event, *Procaimanoidea, Caimanoidea* and *Allognathosuchus* form a more or less diverse but related branch of a distinctive alligatorid group. Whether the family term Allognathosuchidae proposed by Case (1925) should be revived to include all of these transitional forms I am not prepared to recommend at this time, but call attention here to such a possibility in order that this point may be considered by Dr. Mook in his final summation and study of the Crocodilia.

In articles of recent years descriptive of newly discovered specimens of these alligatorid reptiles, there has been considerable speculation and discussion as to their interrelationships with extinct as well as with extant forms. Although some of the conclusions regarding probable phylogenetic lines are interesting speculations, they appear premature in view of the paucity of our knowledge concerning the morphological structures on which many of these discussions have been based. The true relationships of these early alligatorids can only be determined, as first suggested by Patterson (1931), by the discovery of much more and better-preserved materials than are available at the present time.

MANUSCRIPT RECEIVED DECEMBER 13, 1944.

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FULPIA, A NEW UPPER CRETACEOUS BIVALVE MOLLUSK FROM TEXAS AND MARYLAND

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ABSTRACT—A new genus and species, *Fulpia pinguis*, from the Lewisville stratigraphic unit (Upper Cretaceous, Cenomanian) of northeastern Texas, is described and illustrated. The new genus is represented also by shells that are questionably referred to *Fulpia wicomicoensis* (Richards) (=*Corbicula wicomicoensis* Richards) in cores from depths of 1588–1603 feet in an oil-prospecting well, Larry G. Hammond No. 1, drilled by the Ohio Oil Company 6 miles east of Salisbury, Wicomico County, Maryland, and by shells of an unidentified species in a core from the same well at a depth of 2250–2257 feet. The faunal evidence is interpreted to indicate that the Lewisville unit corresponds in age to the fossil-bearing beds in the Maryland well at the depths indicated and to the Raritan formation of Maryland.

THE Upper Cretaceous (Cenomanian) geologic unit in Texas, known as Lewisville (=upper member of the old Woodbine formation of Robert T. Hill, 1901, pp. 293–318), has yielded many new molluscan genera and species, the systematic treatment of which is now well advanced toward completion. Among these new shells is a genus that is of particular interest because it has been identified also in an oil-prospecting well in Maryland. The name *Fulpia*, derived from a local family name in Fannin County, Texas, is proposed for this new genus. The type species, *Fulpia pinguis* Stephenson, occurs abundantly at the type locality in Fannin County and has been collected along the belt of outcrop of the Lewisville unit in every Texas county from Tarrant in the south to Red River in the northeast. At the type locality the shells are in an excellent state of preservation, but elsewhere much of the material is poorly preserved, often in the form of molds in ferruginous sandstone. The species possesses a characteristic outline and form, such that it is usually easily identified, even with imperfectly preserved material. The genus has not been recognized heretofore among the large collections of marine fossils that have been made from Upper Cretaceous formations younger than the Lewisville unit in the Atlantic and Gulf Coastal Plain.

The Maryland well (Larry G. Hammond No. 1) was drilled by the Ohio Oil Company (1944–1945) on the farm of Larry G. Hammond, 6 miles east of Salisbury, Wicomico County (Richards, 1945, pp. 1196–1202). In this well shells of the genus *Fulpia* are present in two core samples between depths of 1,588 and 1,603 feet, and in one sample from depths of 2,250 to 2,257 feet. These shells were submitted to the U. S. Geological Survey by Dr. Joseph T. Singewald, Jr., Director, Department of Geology, Mines, and Water Resources, Maryland. Although most of the shells are more or less crushed and broken and their exteriors poorly preserved, several hinges were uncovered in fairly good

EXPLANATION OF PLATE 12

FIGS. *1–4*—*Fulpia pinguis* Stephenson, n. sp. *1*, Left valve of holotype, ×2, U.S.N.M. 103862. *2*, Posterior view of holotype, ×2. *3*, *4*, Interior views of right and left valves (paratypes), ×2, U.S.N.M. 103863. All are from Sheep Creek, 4 miles northeast of Savoy, Fannin County, Texas. (p. 69)

5–10—*Fulpia wicomicoensis* (Richards)?, (U.S.N.M. 13865). *5*, Interior view of a small right valve, ×8, from Hammond No. 1 well, Maryland, depth 1,588–1,598 feet. *6*, Hinge of a left valve, ×6, from the same source. *7*, *8*, Hinges of right valve, ×3, and left valve, ×2, from the same source, the latter showing an exceptionally thick medial bifid cardinal tooth. *9*, *10*, Interior and exterior views of a right valve, ×2, from the same well, depth 1,598–1,603 feet. (p. 70)

11—*Fulpia* sp. Hinge of left valve, ×4, from the Hammond well, depth 2,250–2,257 feet, showing an exceptionally long anterior cardinal tooth and a deeply bifid medial cardinal tooth. U.S.N.M. 103866. (p. 71)

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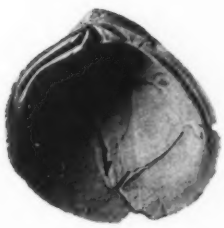
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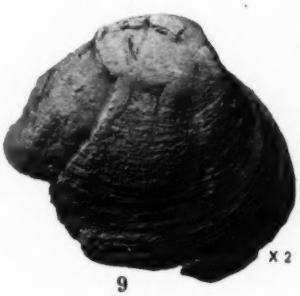

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Stephenson, Upper Cretaceous Mollusk

condition and show conclusively the generic characters of *Fulpia*. In form and outline the shells are very much like *F. pinguis*, but they present slight differences in both ornamentation and dentition that probably justify their specific separation from the Texas species. In the paper just cited Richards briefly describes, without illustrations, a new species, *Corbicula wicomicoensis*, from a depth of 1,588 to 1,598 feet in the Salisbury well, which may belong to *Fulpia*. I have not seen his material. For the time being, therefore, the shells studied by me are referred questionably to his species. These shells certainly do not belong to *Corbicula*.

Several of the faunal elements in the two cores taken between depths of 1,588 and 1,603 feet suggest the age equivalence of these cores with the Raritan formation of Maryland. The following forms may be mentioned: *Breviarca?* sp. (possibly equals *Trigonarca cliffwoodensis* Weller), *Fulpia* sp. (may equal *Astarte veta* Weller), and "*Corbula*" aff. *C. manleyi* Weller. Weller's description of *T. cliffwoodensis* gives no indication of the ligamental apparatus; his *Corbula manleyi* is similar to the related form from the well but appears to be shorter and less slender posteriorly; the type of his *Astarte veta* does not reveal the nature of the hinge, but the form strongly suggests that of the genus *Fulpia* and has little resemblance to the typical *Astarte* Sowerby. This apparent sychroneity with the Raritan formation is in harmony with the suggested age equivalence of the cores with the Lewisville unit, which has long been correlated more or less tentatively with the Raritan. The abundant occurrence of *Fulpia pinguis* in the Lewisville unit and the relative abundance of the closely related species of *Fulpia* in the well cores from a depth of 1,588–1,603 feet in the Salisbury well suggests the approximate synchroneity of the latter with the Lewisville (Cenomanian). Other less clearly defined faunal evidence among the shells associated with *Fulpia* in the Salisbury well tend to confirm this correlation. It is reasonably certain that the bed containing these fossils is not as young as Matawan (Senonian), the age suggested by Richards.

A core sample from a depth of 2,250 to 2,257 feet in the Salisbury well yielded a few incomplete shells of a species that appears to be referable to *Fulpia*, but which are specifically indeterminate. The evidence afforded by this lower bed suggests Lewisville age but is not conclusive. This correlation, if found to be correct, would indicate a thickness of Lewisville equivalents in the Salisbury well of at least 669 feet, an amount much greater than that of the formation as it appears in outcrop in Maryland, Delaware, and New Jersey.

Descriptions of the new genus *Fulpia* and of its type species, *F. pinguis* are given on the following pages. Specimens of *Fulpia*, questionably referred to *F. wicomicoensis* (Richards), from a depth of 1,588 to 1,603 feet in the Hammond well near Salisbury, are described and figured for comparison with the Texas species.

Family CYRENIDAE

Genus FULPIA Stephenson, n. gen.

Type species: *Fulpia pinguis* Stephenson.

Etymology: From *Fulp*, a local family name.

The new genus *Fulpia* is distinguished by its broadly ovate to subtrigonal outline, beaks not strongly prosogyrate and ranging in position from near the midlength to well forward, three cardinal teeth, an anterior lateral tooth in the left valve that extends from just in front of the cardinal area around to and more than halfway past the anterior adductor scar, a still longer posterior lateral that extends in a broad curve from the distal end of the ligament nearly past the posterior adductor scar, a pallial sinus that is narrow, steeply rising, and moderately extended, a smooth inner margin, and a broad lunule not sunken but outlined by an impressed line.

The type species is small, with a maximum measured length of about 20 mm.

FULPIA PINGUIS Stephenson, n. sp.

Plate 12, figures 1–4

Shell small, subovate to subtrigonal in outline, shell wall of medium thickness, moderately inflated, slightly to rather strongly inequilateral, equivalve; there is considerable individual variation in the proportion of length to height and in the degree of inflation, as seen in many individuals from the type locality. Umbonal ridge weak, with a slightly flattened radial

band just back of it. Beaks of medium prominence, incurved, prosogyrate, approximate, situated on different individuals from slightly in advance of the midlength to well toward the front. Lunule long, very broad, slightly concave near the beaks, becoming swollen to a low keel anteriorly, outlined by an impressed line that varies in distinctness on different individuals. Anterodorsal margin steeply descending, slightly arched; anterior margin regularly rounded; ventral margin more broadly rounded than a semicircle; posterior margin rather narrowly rounded below, rounding above into the broadly arched posterodorsal margin. Surface ornamented with fine, closely spaced, sharp-crested, fairly regular concentric ridges, asymmetric in cross section, with the short, steep slope above; on the lunule the concentric markings are finer, sharper, and more regular than on the main surface. Well-preserved specimens show obscure fine radial lining on either side of the umbonal ridge.

Dimensions of the holotype, a shell of medium size, with the two valves intact: length 15 mm., height 14.3 mm., thickness 9.8 mm. The largest shell measured is 20 mm. long and 20.5 mm. high.

Ligament external, about 4 mm. long in the holotype, seated on a narrow, slightly roughened nymph, bordered by a narrow, sharply impressed ligamental groove. Cardinal teeth three in each valve. Anterior cardinal in left valve thin, prominent, weakly bifid, slightly oblique forward; medial cardinal thick, weakly bifid, slightly oblique backward; posterior cardinal thin, rather long, strongly oblique, slightly arched in trend. The anterior separating socket is trigonal, of medium width, profound; posterior socket long, wide, trigonal, slightly arched above; in front of the anterior cardinal is a narrow socket. Anterior left lateral long, thick and rugose at posterior end, becoming thinner and smoother anteriorly along its curved trend, ending a little past the middle of the anterior adductor scar. Posterior left lateral long, narrow, extending from the end of the ligamental groove in a broad curve nearly past the posterior adductor scar. Anterior right cardinal thin, oblique; medial cardinal thick, weakly bifid; posterior cardinal long, thick, oblique, weakly bifid; well-developed claspers receive the long lateral teeth of the left valve. When viewed with sufficient magnification in a strong light very fine transverse striations may be seen on the sides of the laterals of both valves of some shells. Adductor scars small, subequal, not deeply impressed. Pallial line slightly punctate in adults; pallial sinus trigonal, rising steeply, moderately deep, narrowly rounded on inner end. Inner margin smooth.

In many well-preserved specimens from several closely associated concretions restricted to a thickness of about one foot in stratigraphic position, there is a considerable individual variation in outline and in the position of the beak which ranges from slightly in advance of the midlength to well forward; the outline varies from subequilateral-trigonal to slightly elongate-subovate, the latter feature produced by a noticable posteroventral extension of the shell.

Types: Holotype, U.S.N.M. 103862; two figured paratypes, U.S.N.M. 103863; 20 selected unfigured paratypes, U.S.N.M. 103864. From Sheep Creek, 3½ miles northwest of Fulp, Fannin County.

Occurrence: In addition to the type locality in Fannin County, the species has been collected from the Lewisville unit at 17 other localities in Tarrant, Denton, Grayson, Fannin, Lamar, and Red River Counties.

FULPIA WICOMICOENSIS (Richards)?
Plate 12, figures 5–10

Corbicula wicomicoensis RICHARDS, 1945, Am. Assoc. Petroleum Geologists Bull., vol. 29, no. 8, p. 1202.

In outline and form the specimens here referred questionably to Richard's species appear to be closely related to *Fulpia pinguis*, and the hinge is essentially the same, though showing minor differences. As the material is preserved the concentric surface markings appear to be finer and less regular. In the hinge of the left valve both the medial and anterior cardinal teeth are thicker, and the anterior lateral tooth less rugged than are the corresponding features of *F. pinguis;* the thick medial cardinal is also more deeply bifid than in *F. pinguis*. With the available material the differences cited, together with the wide geographic separation, seem to justify treating

the Texas and Maryland shells as separate species.

If correctly identified the specimens should be classed as topotypes of *Fulpia wicomicoensis* Richards, since they came from the same zone in the Larry G. Hammond well No. 1, 6 miles east of Salisbury, Wicomico County, Maryland, depth 1,588 to 1,603 feet, U.S.N.M. 103865.

FULPIA sp.
Plate 12, figure 11

The Larry G. Hammond No. 1 well, 6 miles east of Salisbury, Wicomico County, Maryland, yielded at a depth of 2,250 to 2,257 feet several fragments of bivalve shells that appear to belong to *Fulpia*, but which are too incomplete for specific identification. The hinge of the one left valve illustrated is rather thin and delicate and shows an exceptionally long anterior cardinal tooth and a thick, deeply bifid medial cardinal, U.S.N.M. 103866.

REFERENCES

HILL, ROBERT T., 1901, Geography and geology of the Black and Grand Prairies, Texas: U. S. Geol. Survey Ann. Rept. 21, pt. 7, pp. 293–318.

RICHARDS, HORACE G., 1945, Deep oil test at Salisbury, Wicomico County, Maryland: Am. Assoc. Petroleum Geologists, vol. 29, pp. 1196–1202.

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NEW NAMES FOR HOMONYM SPECIES OF CAMBRIAN HYOLITHIDAE

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AT THE request of Mr. Sinclair the writer proposes the following new names for four Cambrian species of *Hyolithes* whose original names have been found to be homonyms.

Hyolithes walcotti Howell, new name for *Hyolithes curvatus* Walcott, 1890, U. S. Nat. Mus. Proc., vol. 13, pp. 269–270, pl. 20, figs. 7, 7a, preoccupied by *Cleodora curvata* Ludwig, 1864, Palaeontographica, vol. 11, p. 323, pl. 50, figs. 27, 27a, 27b.

Hyolithes resseri Howell, new name for *Hyolithes exilis* Resser and Howell, 1938, Geol. Soc. America Bull., vol. 49, p. 215, pl. 4, figs. 1, 2, preoccupied by *Hyolithes exilis* Stubblefield and Bulman, 1927, Geol. Soc. London Quart. Journ., vol. 83, pp. 126–127, pl. 3, fig. 12.

Hyolithes comptus Howell, new name for *Hyolithes ornatellus* Resser, 1939, Smithsonian Misc. Colls., vol. 97, p. 7, pl. 1, figs. 30–32, preoccupied by *Hyolithus* (*Orthotheca*) *ornatellus* Holm 1893, Sveriges Geologiska Undersökning, Afhandlingar och Uppsatser, ser. C, no. 112, p. 64, pl. 1, figs. 37–40.

Hyolithes endoi Howell, new name for *Hyolithes ornatus* Resser and Endo, 1937, Manchurian Sci. Mus., Bull. 1, p. 151, pl. 29, fig. 1, preoccupied by *Hyolithes* (*Orthotheca?*) *ornatus* Cobbold and Pocock, 1934 Royal Soc. London Philos. Trans., ser. B, vol. 223, p. 338, pl. 40, fig. 6.

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NOTES ON THE NOMENCLATURE OF HYOLITHES

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ABSTRACT—The 383 trivial names used for species of *Hyolithes* and *Orthotheca*, Palaeozoic incertae sedis, are listed with references. Four homonyms are replaced.

PREPARATION of the "pteropod" section of the Card Catalogue of Devonian Fossils has required a comprehensive study of the genera involved. One result has been an appreciation of the need for intensive revision of the species now assigned to the genus *Hyolithes* Eichwald, 1840 (*Hyolithus* of some authors). Others have pointed out the need, but the task is one of large scope and has not attracted workers. Holm's monograph of 1893 on the Swedish Cambrian, Ordovician and Silurian forms remains the only comprehensive review of the field, although it did not treat the later Palaeozoic, and scores of species have been described in the last fifty years.

Attempts to define subgeneric groups have not met with acceptance, in spite of the great diversity of form and ornament shown by different species. The only subgenus used by recent workers is *Orthotheca* Novák, 1886, which is considered by some to have generic status, by others to rank as a subgenus of *Hyolithes*. However, other groups have been proposed, and it is probable that many of them will be found useful when the genus is fully studied.

Three hundred and sixty-three species or subspecies have been referred to *Hyolithes* at one time or another, besides 20 others described as *Orthotheca* which would be placed here by many workers. The genus is reported throughout the Palaeozoic, and species have also been described from the Triassic and Miocene. The forms are distributed in the Palaeozoic as follows: Cambrian, 177; Ordovician, 111; Silurian, 29; Devonian, 53; Carboniferous, 7; Permian, 3. Because of this wide distribution it has been thought useful to prepare a list of the species and subspecies, with brief references. This will indicate the names that are still available, and at the same time provide a basis for future work on the group. Mr. R. A. C. Brown of the Bureau of Geology and Topography, Ottawa, and Dr. B. F. Howell have kindly checked some references for me. I doubt that the list is complete, and shall welcome notice of omissions and inaccuracies.

Dr. Howell and Dr. J. Stewart Williams have provided new names for some homonyms in notes appended to this paper, and four others are proposed here.

HYOLITHES MATTHEWI Sinclair, new name

Hyolithes decipiens Matthew [not Barrande], 1894, Royal Soc. Canada Trans., vol. 11, sec. 4, p. 96, pl. 16, fig. 11; 1894, New York Acad. Sci. Trans., vol. 14, p. 130, pl. 6, fig. 2; Hayes and Howell, 1937, Geol. Soc. America Special Papers 5, p. 86.

This combination was not available to Matthew, as it had been used by Barrande in 1867. The type specimens came from the Lower Cambrian Hanford Brook formation on Hanford Brook, St. John County, New Brunswick. Three cotypes are in the Royal Ontario Museum of Palaeontology, number 7829.

HYOLITHES HANFORDENSIS Sinclair, new name

Diplotheca acadica obtusa Matthew, 1886, Royal Soc. Canada Trans., vol. 3, sec. 4, p. 55, pl. 6, fig. 8.

Hyolithus acadicus obtusus (Matthew) Holm [not Salter], 1893, Sver. geol. Unders. C 112, p. 29.

When Holm referred Matthew's subspecies to *Hyolithus* it became a homonym of *Theca obtusa* Salter, 1866, which he referred to the same genus. Matthew's form, which is here considered to have specific rank, was found in the Lower Cambrian Hanford Brook formation on Hanford Brook, St. John County, New Brunswick. The holotype is in the Royal Ontario Museum of Palaeontology, number 7692.

HYOLITHES HALLI Sinclair, new name

Hyolithes striatus Hall [not Eichwald], 1876, Illustr. Devonian Fossils, pl. 27, fig. 8, 9, 12; Paleontology New York, vol. 5, pt. 2, p. 199, pl. 32, fig. 31, 34. Cleland, 1903, U. S. Geol. Survey Bull. 206, p. 77.

This combination is not available to Hall, as it had been used by Eichwald in 1860. Hall's species came from the Middle Devonian Hamilton group at Norton's Landing (Shurgar Point), Tompkins County, New York. Drs. Winifred Goldring and R. H. Flower tell me that the horizon is probably the King Ferry member of the Ludlowville. The holotype is in the New York State Museum, number 11028/1.

HYOLITHES MILLERI Sinclair, new name

Hyolithes lanceolatus Miller [not (Morris)], 1894, Indiana Geol. Survey 18th Rept. p. 317, pl. 9, fig. 35–36. Branson, 1938, Univ. Missouri Studies, vol. 13, pt. 3, p. 111, pl. 9, fig. 19.

This combination was not available to Miller, as Morris' *Theca lanceolata* had been referred to *Hyolithus* by Barrande in 1867. Miller's species came from the Lower Mississippian Chouteau formation at Sedalia, Missouri. The cotypes are in the University of Cincinnati Museum, numbers 3899, 3900.

LIST OF NAMES USED FOR HYOLITHES

In this list all trivial names are entered as species, in order to permit alphabetical arrangement. Most of them seem to be species rather than subspecies in any real sense of that word. Throughout, *H.* and *O.* refer to *Hyolithes* and *Orthotheca*. Species described as *Hyolithus* are entered as *H.*, as it does not seem profitable to distinguish them from those spelled correctly. All species referred to both *Hyolithes* and *Orthotheca* are listed as "*H.* (*O.*)." This is in keeping with much modern practice, and has the advantage here of simplicity and brevity. It does not reflect the writer's opinion, which is that *Orthotheca* is a genus, but this paper is concerned with the present nomenclatural status of these names, and not with their future disposal. For the same reason no attempt is made to indicate synonymy, except in the case of replaced homonyms. Various authors have pointed out that some of these names refer to trilobite fragments, conularids, etc., and some have been considered synonyms of others. All references are to the original publication of the valid name; *nomina nuda* are not included.

H. acadicus Walcott, 1884, p. 20, pl. 2, fig. 5. L. Cambrian; New Brunswick.

H. aclis Hall, 1876, pl. 27, figs. 5–7, 10–11. M. Devonian; New York.

H. aculeatus (Hall), 1860, p. 107 (as *Pugiunculus? (Theca) aculeatus*). Mississippian; Indiana.

H. acutus Eichwald, 1840, p. 97. Ordovician; Esthonia.

H. aduncus Barrande, 1867, p. 76, pl. 12, figs. 24–32. Silurian; Bohemia.

H. (O.) advena Reed, 1915, p. 20, pl. 4, fig. 5. U. Ordovician; Burma.

H. (O.) aemulus Holm, 1893, p. 62, pl. 5, figs. 72–76. L. Ordovician; Sweden.

H. aequilateralis Cobbold, 1919, p. 153, pl. 4, figs. 21–22. L. Cambrian; England.

H. (O.) affinis Holm, 1893, p. 60, pl. 1, figs. 57–59; pl. 5, figs. 59–63; pl. 6, fig. 11. M. Cambrian; Sweden.

H. alatus Whiteaves, 1892, p. 342, pl. 46, figs. 2–4. Devonian; Manitoba.

H. alatus Cobbold, 1919, p. 151, pl. 4, figs. 13–16. L. Cambrian; England.

H. aliger Resser & Endo, 1937, p. 148, pl. 28, figs. 11–13. M. Cambrian; China.

H. alter Barrande, 1867, p. 76, pl. 15, figs. 27–31. M. Devonian; Bohemia.

H. americanus Billings, 1872, p. 215, fig. 2. L. Cambrian; New York.

H. anceps (Münster), 1840, p. 104, pl. 9, fig. 6 (as *Orthoceras anceps*). Devonian; Germany.

H. anceps (Salter), 1848, p. 355, pl. 14, fig. 1 (as *Theca anceps*). M. Silurian; England.

H. anglicus Cobbold & Pocock, 1934, p. 334, pl. 39, fig. 29 (as *H. tenuistriatus anglicus*). M. Cambrian; England.

H. angustus Cobbold & Pocock, 1934, p. 336, pl. 40, fig. 27 (as *H. araneus angustus*). M. Cambrian; England.

H. antiquus (Hicks), 1871, p. 400, pl. 16, fig. 13 (as *Theca antiqua*). Cambrian; Wales.

H. aplatus Resser & Endo, 1937, p. 148, pl. 28, figs. 5–7. M. Cambrian; China.

H. araneus Holm, 1893, p. 80, pl. 5, fig. 78. M. Cambrian; Sweden.

H. aratus (Salter), 1866, p. 352, pl. 10, figs. 15, 21 (as *Theca arata*) U. Cambrian; Wales.

H. arcuatus Barrande, 1867, p. 77, pl. 12, figs. 38–41. L. Devonian; Bohemia.

H. ardmillensis Reed, 1909, p. 203, pl. 1, figs. 1–6. M. Ordovician; Scotland.

H. arenophilus Holm, 1893, p. 71, pl. 1, figs. 78–81; pl. 2, figs. 1, 2. M. Cambrian; Sweden.

H. assulatus Groom, 1902, p. 119, fig. 26. Cambrian; England.

H. asteroideus Reed, 1909, p. 205, pl. 1, figs. 7–9. U. Ordovician; Scotland.

H. (O.) attenuatus (Walcott), 1890, p. 269, pl. 20, fig. 11 (as *H. attenuatus*). U. Cambrian; Nevada.

H. avonensis Lochman, 1940, p. 23, pl. 2, fig. 7. U. Cambrian; Missouri.

H. (O.) avus Holm, 1893, p. 50, pl. 1, fig. 13 (as *H. (O.) corneolus avus*). L. Cambrian; Sweden.

H. baconi Whitfield, 1878, p. 77. M. Ordovician; Wisconsin.

H. (O.) baculoides (Novák), 1891, p. 36, pl. 2, figs. 1–4 (as *O. baculoides*). Silurian; Bohemia.

H. barrandei (Novák), 1891, p. 32, pl. 1, figs. 12–22 (as *Ceratotheca barrandei*). Silurian; Bohemia.

H. (O.) bayonet (Matthew), 1899, p. 193, pl. 3, fig. 1 (as *O. bayonet*). L. Cambrian; Newfoundland.

H. beirensis (Sharpe), 1853, p. 158, pl. 9, fig. 19 (as *Theca beirensis*). Ordovician; Portugal.

H. belswardinensis Stubblefield & Bulman, 1927, p. 125, pl. 3, figs. 10, 11. U. Cambrian; England.

H. benignensis Novák, 1891, p. 12. Ordovician; Bohemia.

H. biconvexus Cobbold, 1919, p. 152, pl. 4, figs. 10–12. L. Cambrian; England.

H. bicostatus Novák, 1891, p. 13, pl. 5, figs. 24–27. L. Devonian; Bohemia.

H. bijugosus (Salter), 1866, p. 351, pl. 10, figs. 19, 20 (as *Theca bijugosa*). U. Cambrian; Wales.

H. billingsi Walcott, 1886, p. 134, pl. 13, fig. 1. L. Cambrian; Labrador. (Proposed for *H. obtusus* (Billings) 1861, on the mistaken assumption that this was preoccupied by *H. obtusus* (Salter) 1866.)

H. bisulcatus Holm, 1893, p. 102, pl. 6, figs. 12–15. L. Ordovician; Sweden.

H. brevis Cobbold, 1920, p. 355, pl. 24, fig. 32 (as *H. strettonensis brevis*). L. Cambrian; England.

H. brŏggeri Holm, 1893, p. 30. Cambrian; Norway.

H. caelatus Holm, 1893, p. 79, pl. 6, figs. 18–20. L. Ordovician; Sweden.

H. (O.) caereesiensis (Hicks), 1875, p. 189, pl. 11, fig. 7 (as *Theca caereesiensis*). L. Ordovician; Wales.

H. calceus Novák, 1891, p. 14, pl. 4, figs. 27–30. Silurian; Bohemia.

H. canalis Resser & Endo, 1937, p. 154, pl. 29, fig. 7. M. Cambrian; China.

H. candidus Reed, 1909, p. 205, pl. 1, figs. 10–13. U. Ordovician; Scotland.

H. capensis Reed, 1925, p. 102, pl. 7, fig. 2 (as *H. d'orbignyi capensis*). Devonian; South Africa.

H. carbonaria Walcott, 1884a, p. 264, pl. 23, fig. 3. Mississippian; Nevada.

H. carinatus Matthew, 1899b, p. 42, pl. 1, fig. 5. U. Cambrian; British Columbia.

H. cariniferus Resser & Endo, 1937, p. 156, pl. 40, figs. 8–10. M. Cambrian; China.

H. catenatus Barrande, 1867, p. 77, pl. 13, figs. 17–21. L. Devonian; Bohemia.

H. caudatus (Matthew), 1886, p. 53, pl. 6, fig. 5 (as *Diplotheca hyattiana caudata*). Cambrian; New Brunswick.

H. cecrops Walcott, 1917, p. 27, pl. 5, fig. 3. M. Cambrian; British Columbia.

H. centennialis Barrett, 1876, p. 299. L. Devonian; New York.

H. ceratophilus Clarke, 1894, p. 172, pl. 4, figs. 17, 18. L. Devonian; New York.

H. cinctus Barrande, 1867, p. 78, pl. 9, figs. 8–12; pl. 15, figs. 25, 26. L. Ordovician; Bohemia.

H. cliftonensis Foerste, 1909, p. 62, pl. 3, fig. 38. L. Silurian; Tennessee.

H. clivei Reed, 1915, p. 18, pl. 3, figs. 18, 19. U. Ordovician; Burma.

H. columbanus Reed, 1909, p. 206, pl. 1, fig. 14. U. Ordovician; Scotland.

H. (O.) columnaris (Barrande), 1867, p. 78, pl. 9, fig. 13; pl. 12, figs. 13–23. (as *H. columnaris*). Silurian; Bohemia.

H. cometoides (Baily), 1862, p. 305, pl. 4, fig. 8 (as *Theca cometoides*). M. Ordovician; Ireland.

H. comleyensis Cobbald, 1931, p. 91, pl. 41, fig. 6 (as *H. similis comleyensis*). L. Cambrian; England.

H. (O.) communis (Billings), 1872, p. 214, fig. 1 (as *H. communis*). M. Cambrian; Quebec.

H. (O.) compressus Cobbold, 1920, p. 357, pl. 24, fig. 27. L. Cambrian; England.

H. comptus Howell, 1946, see page 71. M. cambrian; Idaho.

H. concinnus Holm, 1893, p. 103, pl. 2, figs. 24–28. M. Ordovician; Sweden.

H. confusus Holm, 1893, p. 74, text fig. L. Cambrian; Sweden.

H. contortus Barrande, 1867, p. 60. Ordovician; Germany.

H. conularioides Tate, 1892, p. 186, pl. 2, fig. 1. Cambrian; South Australia.

H. cooperi Williams, 1946, see below, page 87. M. Devonian; New York.

H. (*O.*) *cor* Holm, 1893, p. 58, pl. 1, figs. 60–62; pl. 6, fig. 10. M. Cambrian; Sweden.

H. (*O.*) *corneolus* Holm, 1893, p. 50, pl. 5, figs. 57–58. M. Cambrian; Sweden.

H. corrugatus (Salter), 1864, p. 238, pl. 13, fig. 10 (as *Theca corrugata*). U. Cambrian; Wales.

H. corrugatus Walcott, 1890a, p. 270, pl. 20, fig. 9 (as *H.? corrugatus*). U. Cambrian; Nevada.

H. corrugatus Kiaer, 1917, p. 25, pl. 3, fig. 9. L. Cambrian; Norway.

H. costatus Matthew, 1901, fig. 3. U. Cambrian; British Columbia. (In error for *H. carinatus?*).

H. costatulus Barrande, 1867, p. 79, pl. 13, figs. 41–44. L. Devonian; Bohemia.

H. cowanensis Resser, 1938b, p. 47, pl. 15, figs. 33–35. U. Cambrian; Alabama.

H. crassus (Matthew), 1886, p. 55, pl. 6, fig. 9 (as *Diplotheca acadica crassa*). L. Cambrian; New Brunswick.

H. crassus Cobbold, 1920, p. 354, pl. 24, fig. 28. L. Cambrian; England.

H. crebescens Resser & Endo, 1937, p. 151, pl. 28, figs. 15–17; pl. 29, figs. 5, 6. M. Cambrian; China.

H. crispatus (Boll), 1859, p. 162 (as *Theca crispata*). Ordovician; Germany.

H. crispissimus Holm, 1893, p. 94, pl. 3, figs. 48–52; pl. 6, fig. 28 (as *H. crispatus crispissimus*). M. Ordovician; Sweden.

H. crispulus Holm, 1893, p. 94, pl. 3, figs. 36–45 (as *H. crispatus crispulus*). M. Ordovician; Sweden.

H. crowelli Roy, 1941, p. 123, fig. 90. U. Ordovician; Baffinland.

H. cultellus Novák, 1891, p. 15, pl. 5, figs. 14–17. Silurian; Bohemia.

H. curticei Resser, 1938b, p. 47, pl. 15, figs. 36–38. U. Cambrian; Tennessee.

H. curvatus (Ludwig), 1864, p. 323, pl. 50, fig. 27 (as *Cleodora curvata*). Devonian; Germany.

H. (*O.*) *curvatus* (Walcott), 1890a, p. 269, pl. 20, fig. 7 (as *H. curvatus*). U. Cambrian; Nevada. (Name replaced by *H. walcotti* Howell, 1946.)

H. cuspidatus (Salter), 1866, p. 353, pl. 10, fig. 25 (as *Theca* (*Centrotheca*) *cuspidata*). U. Cambrian; Wales.

H. cybele Walcott, 1905, p. 17. M. Cambrian; China.

H. cymbium Holm, 1893, p. 82, pl. 3, figs. 6–15. M. Ordovician; Sweden.

H. (*O.*) *cyrene* (Walcott), 1905, p. 18 (as *O. cyrene*). U. Cambrian; China.

H. danianus Walcott, 1884, p. 20, pl. 2, fig. 7. Cambrian; New Brunswick.

H. daphnis Walcott, 1905, p. 18. U. Cambrian; China.

H. dartae Northrop, 1939, p. 217, pl. 25, fig. 7; pl. 28, fig. 7. M. Silurian; Quebec.

H. davidii (Hicks), 1872a, p. 50, pl. 2, figs. 28, 29 (as *Theca davidii*). U. Cambrian; Wales.

H. decipiens Barrande, 1867, p. 80, pl. 12, figs. 33–37. Ordovician; Bohemia.

H. decipiens Matthew, 1894, p. 96, pl. 16, fig. 11. L. Cambrian; New Brunswick. (Name replaced by *H. matthewi* Sinclair, new name.)

H. (*O.*) *degeeri* Holm, 1893, p. 54, pl. 1, figs. 25–27. L. Cambrian; Sweden.

H. (*O.*) *deletus* (Novák), 1891, p. 35, pl. 6, figs. 17–21 (as *Bactrotheca deleta*). Ordovician; Bohemia.

H. delia Walcott, 1905, p. 18. L. Cambrian; China.

H. (*O.*) *delphus* (Walcott), 1905, p. 20 (as *O. delphus*). M. Cambrian; China.

H. (*O.*) *dens* Holm, 1893, p. 63, pl. 1, figs. 47–50; pl. 5, fig. 77. L. Ordovician; Sweden.

H. discors (Barrande), 1847, p. 557, pl. 4, fig. 5 (as *Pugiunculus discors*). L. Devonian; Bohemia.

H. dispar Holm, 1893, p. 85, pl. 3, figs. 23–30. M. Ordovician; Sweden.

H. divaricatus Schwarzbach, 1934, p. 16, fig. 18. Cambrian; Germany.

H. d'orbignyi Kozlowski, 1923, p. 71, pl. 10, figs. 8–11. Devonian; Bolivia.

H. (*O.*) *dryas* (Walcott), 1905, p. 19 (as *O. cyrene dryas*). M. Cambrian; China.

H. dubius Miller & Faber, 1894, p. 155, pl. 8, fig. 23 (as *H.? dubius*). U. Ordovician; Indiana.

H. ejpovicensis Želízsko, 1911, p. 49, pl. 4, fig. 7. L. Ordovician; Bohemia.

H. elegans (Barrande), 1847, p. 557, pl. 4, fig. 3 (as *Pugiunculus elegans*). Ordovician; Bohemia.

H. elegantulus (Kjerulf), 1865, p. 13, fig. 20

(as *Theca norvegica elegantula*). Ordovician; Norway.

H. elongatus Barrande, 1867, p. 82, pl. 9, figs. 5–7. M. Ordovician; Bohemia.

H. (*O.*) *emmonsi* (Ford), 1873, p. 214, fig. 3 (as *H. emmonsi*). M. Cambrian; New York.

H. endoi Howell, 1946, see page 71. M. Cambrian; China.

H. erraticus Koken, 1889, p. 81, pl. 8, fig. 3. Ordovician; Germany.

H. esthonus Koken, 1889, p. 81, pl. 8, fig. 4. Ordovician; Esthonia.

H. euglyphus Novák, 1886, p. 26, pl. 2, figs. 1–10. Ordovician; Bohemia.

H. exaratus Hadding, 1913, p. 64, pl. 6, fig. 1. L. Ordovician; Sweden.

H. (*O.*) *excavatus* Holm, 1893, p. 61, pl. 1, figs. 63, 64; pl. 5, figs. 67–71. M. Cambrian; Sweden.

H. excellens Billings, 1872a, p. 471, fig. 8. Cambrian; Newfoundland.

H. (*O.*) *exilis* Stubblefield & Bulman, 1927, p. 126, pl. 3, fig. 12. U. Cambrian; England.

H. exilis Resser & Howell, 1938, p. 215, pl. 4, figs. 1, 2. L. Cambrian; Virginia. (Name replaced by *H. resseri* Howell, 1946.)

H. expansus Holm, 1893, p. 76, pl. 2, fig. 7. Silurian; Sweden.

H. fabaceus Hede, 1915, pp. 37, 61, pl. 3, figs. 14, 15. U. Silurian; Sweden.

H. fallax Holm, 1893, p. 84, pl. 2, figs. 37–41 (as *H. cymbium fallax*). M. Ordovician; Sweden.

H. fasciculatus (G. & F. Sandberger), 1866, p. 245, pl. 21, fig. 5 (as *Pugiunculus fasciculatus*). Devonian; Germany.

H. (*O.*) *fibrosus* Troedsson, 1918, p. 45, pl. 2, fig. 30. U. Ordovician; Sweden.

H. (*O.*) *fistula* (Holl), 1865, p. 102, fig. 7 (as *Serpulites fistula*). Cambrian; England.

H. (*O.*) *fluctuosus* Holm, 1893, p. 68, pl. 3, figs. 53–57; pl. 5, figs. 88–91. U. Ordovician; Sweden.

H. forbesii (Sharpe), 1845, p. 314, pl. 13, fig. 1 (as *Theca forbesii*). M. Silurian; Wales.

H. fortis Barrande, 1867, p. 82, pl. 15, figs. 16–21. L. Ordovician; Bohemia.

H. (*O.*) *fragilis* (Novák), 1891, p. 38, pl. 2, figs. 33–35 (as *O. fragilis*). Silurian; Bohemia.

H. fuchouensis Resser & Endo, 1937, p. 155, pl. 29, fig. 7. M. Cambrian; China.

H. gallatinensis Resser, 1938a, p. 21. U. Cambrian; Wyoming.

H. gibbosus Hall & Whitfield, 1873, p. 242, pl. 11, figs. 1–3. U. Cambrian; New York.

H. giganteus Novák, 1891, p. 19, pl. 4, figs. 40–50. Ordovician; Bohemia.

H. girvanensis Reed, 1909, p. 206, pl. 1, figs. 15–17. M. Ordovician; Scotland.

H. (*O.*) *glaber* (Walcott), 1911, p. 75, pl. 14, fig. 5 (as *O. glabra*). M. Cambrian; China.

H. globiger Saito, 1936, p. 361, pl. 3, figs. 13–17. M. Cambrian; Korea.

H. gracilior Matthew, 1895, p. 130, pl. 6, fig. 3. L. Cambrian; New Brunswick.

H. gracilis (Matthew), 1886, p. 50, pl. 6, fig. 2 (as *H.* (*Camerotheca*) *gracilis*). L. Cambrian; New Brunswick.

H. gracillimus Matthew, 1901a, p. 109, fig. 3 (as *H. gracilis gracillimus*). L. Cambrian; New Brunswick.

H. granulatus (Boll), 1859, p. 162 (as *Theca granulata*). Ordovician; Germany.

H. (*O.*) *granuliferus* Reed, 1909, p. 213, pl. 2, figs. 24, 25 (as *H.* (*O.*) *thraivensis granuliferus*). U. Ordovician; Scotland.

H. gregarius (Meek & Hayden), 1861, p. 436 (as *Theca* (*Pugiunculus*) *gregaria*). U. Cambrian; Wyoming.

H. (*O.*) *groenlandicus* Poulsen, 1932, p. 20, pl. 3, figs. 1–3 (as *H.* (*O.*) *bayonet groenlandicus*). L. Cambrian; Greenland.

H. (*O.*) *guiraudi* Thoral, 1935, p. 153, pl. 14, figs. 1–6. U. Cambrian; France.

H. halli Sinclair, 1946, see above, page 72. M. Devonian; New York.

H. hanfordensis Sinclair, 1946, see above, page 72. L. Cambrian; New Brunswick.

H. hanusi Zázvoka, 1930, p. 35, pl. 1, figs. 10–16. L. Ordovician; Bohemia.

H. (*O.*) *harknessi* (Hicks), 1875, p. 189, pl. 10, fig. 11 (as *Theca harknessi*). L. Ordovician; Wales.

H. hathewayi Matthew, 1899a, p. 73, pl. 3, fig. 5. L. Cambrian; Newfoundland.

H. haywardensis Grabau, 1900, p. 653, pl. 32, fig. 11 (as *H.? haywardensis*). M. Cambrian; Massachusetts.

H. hercynicus (Roemer), 1866, p. 208, pl. 34, fig. 6 (as *Theca hercynica*). Devonian; Germany.

H. (*O.*) *hermelini* Holm, 1893, p. 52. pl. 1, figs. 34–36. L. Cambrian; Sweden.

H. heroicus Holm, 1893, p. 75, pl. 2, figs. 42–45. U. Ordovician; Sweden.

H. heros Hall, 1888, p. 7, pl. 114, figs. 24–27. L. Devonian; New York.

H. hexagonus Barrande, 1867, p. 83, pl. 13, figs. 31–33. L. Devonian; Bohemia.

H. hofensis Barrande, 1868, p. 689 fig. 57. Ordovician; Germany.

H. (*O.*) *holmi* Cobbold, 1931, p. 494, pl. 41, fig. 13. L. Cambrian; England.

H. homfrayi Reed, 1902, p. 124, pl. 6, fig. 3. M. Cambrian; Wales.

H. hospes Holm, 1893, p. 107, pl. 5, figs. 12–16. M. Ordovician; Sweden.

H. hyattianus (Matthew), 1886, p. 52, pl. 6, fig. 4 (as *Diplotheca hyattiana*). L. Cambrian; New Brunswick.

H. idahoensis Resser, 1938, p. 5, pl. 1, figs. 57, 58. M. Cambrian; Idaho.

H. immemor Reed, 1909, p. 207, pl. 1, figs. 18–21; pl. 2, fig. 1. M. Ordovician; Scotland.

H. impar Ford, 1872, p. 419, figs. 1, 2. M. Cambrian; New York.

H. imperfectus Barrande, 1868, p. 688, fig. 56. Ordovician; Germany.

H. inaequilateralis Foerste, 1889, p. 262. L. Cambrian; Massachusetts.

H. inaequistriatus Remelé, 1888, p. 670, pl. 28, figs. 4–6. Ordovician; Germany.

H. inaequistriatus Williams, 1935, p. 851, pl. 60, figs. 21, 25. M. Devonian; New York. (Name replaced by *H. cooperi* Williams, 1946.)

H. incurvatus Novák, 1891, p. 20, pl. 6, figs. 13–16. L. Devonian; Bohemia.

H. indistinctus Barrande, 1867, p. 83, pl. 9, figs. 1–4. Ordovician; Bohemia.

H. innotatus Holm, 1893, p. 104, pl. 2, figs. 12–16. M. Ordovician; Sweden.

H. insularis Eichwald, 1860, p. 1046, pl. 41, fig. 13. Ordovician; Esthonia.

H. insularis Moberg, 1892, p. 117, pl. 3, fig. 18. L. Cambrian; Sweden. (Name replaced by *H. confusus* Holm, 1893.)

H. (*O.*) *intermedius* Novák, 1886, p. 7, pl. 1, figs. 9–13; pl. 2, figs. 11–17. L. Devonian; Bohemia.

H. (*O.*) *irravadicus* Reed, 1915, p. 19, pl. 3, fig. 20. U. Ordovician; Burma.

H. (*O.*) *johnstrupi* Holm, 1893, p. 56, pl. 1, figs. 28–33, 71. L. Cambrian; Denmark.

H. journeauxi Northrop, 1939, p. 217, pl. 25, figs. 8, 9. M. Silurian; Quebec.

H. kirkbyi (Howse), 1857, p. 472, pl. 4, fig. 27 (as *Theca? kirkbyi*). Permian; England.

H. kloučeki Zázvoka, 1930, p. 36, pl. 2, figs. 11–17. L. Ordovician; Bohemia.

H. kolihai Zázvoka, 1930, p. 37, pl. 3, figs. 10–12. L. Ordovician; Bohemia.

H. kotôi Saito, 1936, p. 361, pl. 3, figs. 20–23. M. Cambrian; Korea.

H. kuantungensis Resser & Endo, 1937, p. 146, pl. 18, fig. 9. L. Cambrian; China.

H. kussokensis Waagen, 1891, p. 101, pl. 1, figs. 6–11. Cambrian; India.

H. laevigatus Linnarsson, 1871, p. 9, pl. 1, fig. 1. Cambrian; Sweden.

H. lanceola Holm, 1893, p. 74, pl. 2, figs. 3–6. Silurian; Sweden.

H. lanceolatus (Morris), 1845, p. 289, pl. 18, fig. 8 (as *Theca lanceolata*). Permian; New South Wales.

H. lanceolatus Miller, 1894, p. 317, pl. 9, figs. 35, 36. Mississippian; Missouri. (Name replaced by *H. milleri* Sinclair, new name.)

H. latissimus Koken, 1889, p. 82, pl. 8, fig. 5. Cambrian; Esthonia.

H. latus Eichwald, 1860, p. 1045, pl. 40, fig. 16. Ordovician; Esthonia.

H. latus Zázvoka, 1930, p. 39, pl. 3, figs. 7–9 (as *H. pauxillus latus*). L. Ordovician; Bohemia.

H. laubei Barrande, 1877, p. 297, pl. 470, figs. 11–13. M. Devonian; Bohemia.

H. lenticularis Holm, 1893, p. 77, pl. 5, figs. 23–28. L. Cambrian; Denmark.

H. leptus Chapman, 1902, p. 119, pl. 18, fig. 15. L. Ordovician; Victoria.

H. ligea (Hall), 1862, p. 62 (as *Theca ligea*). M. Devonian; New York.

H. (*O.*) *lineatulus* Holm, 1893, p. 59, pl. 1, figs. 53–56; pl. 5, figs. 64–66. M. Cambrian; Sweden.

H. lineatus (Kjerulf), 1865, p. 12, fig. 19 (as *Theca lineata*). Ordovician; Norway.

H. lineatus (Richter), 1865, p. 370, pl. 11, fig. 6 (as *Cleodora lineata*). Devonian; Germany.

H. (*O.*) *lineatus* (Callaway), 1877, p. 668, pl. 24, fig. 9 (as *Theca lineata*). U. Cambrian; England.

H. lineolatus (Salter), 1865, page not known (as *Theca lineolata*). Ordovician; India.

H. (*O.*) *loczyi* Reed, 1915, p. 19, pl. 3, fig. 21; pl. 4, figs. 1–4. U. Ordovician; Burma.

H. longissimus (Ludwig), 1864, p. 323, pl. 50, fig. 25 (as *Cleodora longissima*). Devonian; Germany.

H. (*O.*) *longus* Poulsen, 1932, p. 20, pl. 3,

fig. 4 (as *H.* (*O.*) *bayonet longus*). L. Cambrian; Greenland.

H. magister Barrande, 1867, p. 84, pl. 15, figs. 37–39. Ordovician; Bohemia.

H. magnificus Stubblefield & Bulman, 1927, p. 124, pl. 3, figs. 6–9, ? 14. U. Cambrian; England.

H. malvernensis Groom, 1902, p. 115, figs. 10–15. Cambrian; England.

H. mantouensis Resser & Endo, 1937, p. 152, pl. 28, figs. 8–10. M. Cambrian; China.

H. matthewi Sinclair, 1946, see above, page 72. L. Cambrian; New Brunswick.

H. maximus Barrande, 1867, p. 85, pl. 10, figs. 22–29. M. Cambrian; Bohemia.

H. (*O.*) *mickwitzi* Öpik, 1926, p. 46. Cambrian; Esthonia.

H. (*O.*) *micmac* (Walcott), 1884, p. 21, pl. 2, fig. 6 (as *H. micmac*). Cambrian; New Brunswick.

H. milleri Sinclair, 1946, see above, page 73. Mississippian; Missouri.

H. mimicus Cobbold, 1931, p. 490, pl. 41, fig. 10. L. Cambrian; England.

H. miseneri (Foerste), 1917, p. 42, pl. 1, fig. 1 (as *Conularia miseneri*). U. Ordovician; Indiana.

H. mobergi Troedsson, 1918, p. 43, pl. 2, figs. 27–29. U. Ordovician; Sweden.

H. multicinctus Bradley, 1930, p. 240, pl. 25, fig. 13. M. Ordovician; Missouri.

H. multipunctatus Reed, 1909, p. 208, pl. 2, fig. 2. M. Ordovician; Scotland.

H. (*O.*) *multistriatus* Harrington, 1937, p. 109, pl. 5, fig. 1. L. Ordovician; Argentina

H. mutatus Poulsen, 1932, p. 23, pl. 3, figs. 12–17. L. Cambrian; Greenland.

H. narthorsti Holm, 1893, p. 87, pl. 1, figs. 65–70. L. Cambrian; Denmark.

H. neapolis Clarke, 1885, p. 56, pl. 3, figs. 4, 5. U. Devonian; New York.

H. newsomensis Foerste, 1903, p. 707. M. Silurian; Tennessee.

H. (*O.*) *newtoni* (Walcott), 1890a, p. 270, pl. 20, fig. 4 (as *H. newtoni*). U. Cambrian; South Dakota.

H. nobilis Barrande, 1867, p. 85, pl. 13, figs. 22–26. M. Cambrian; Bohemia.

H. norvegicus (Kjerulf), 1865, p. 13, fig. 18 (as *Theca norvegica*). Ordovician; Norway.

H. (*O.*) *novellus* (Barrande), 1867, p. 86, pl. 15, fig. 23; pl. 16, fig. 18 (as *H. novellus*). U. Devonian; Bohemia.

H. obesus Holm, 1893, p. 75, pl. 5, figs. 48–53. M. Cambrian; Sweden.

H. obscurus Holm, 1893, p. 76, pl. 5, figs. 29–31, ?32–33. M. Cambrian; Sweden.

H. obtusus (Billings), 1861, p. 955 (as *Salterella obtusa*). L. Cambrian; Labrador.

H. obtusus (Salter), 1866, p. 352, fig. 117 (as *Theca obtusa*). U. Cambrian; Wales.

H. obtusus (Matthew), 1886, p. 55, pl. 6, fig. 8 (as *Diplotheca acadica obtusa*). Cambrian; New Brunswick. (Name replaced by *H. hanfordensis* Sinclair, new name.)

H. obvius Barrande, 1867, p. 86, pl. 12, figs. 1–6; ? pl. 15, fig. 22. Silurian; Bohemia.

H. ölandicus Holm, 1893, p. 70, pl. 5, figs. 44–47. M. Cambrian; Sweden.

H. onychia Spreisterbach & Fuchs, 1909, page not known. Devonian; Germany.

H. operculatus (Salter), 1866, p. 35, pl. 10, figs. 22–24 (as *Theca* (*Cleidotheca*) *operculata*). U. Cambrian; Wales.

H. operosus Cobbold & Pocock, 1934, p. 335, pl. 41, figs. 1–5. M. Cambrian; England.

H. orientalis Waagen, 1880, p. 177 pl. 8, fig. 3. Cambrian; India.

H. (*O.*) *ornatellus* Holm, 1893, p. 64, pl. 1, figs. 37–40. U. Ordovician; Sweden.

H. ornatellus Resser, 1939, p. 7, pl. 1, figs. 30–32. M. Cambrian; Idaho. (Name replaced by *H. comptus* Howell, 1946).

H. (*O.*) *ornatus* Cobbold & Pocock, 1934, p. 338, pl. 40, fig. 6 (as *H.* (*O.?*) *ornatus*). M. Cambrian; England.

H. ornatus Resser & Endo, 1937, p. 151, pl. 29, fig. 1. M. Cambrian; China. (Name replaced by *H. endoi* Howell, 1946.)

H. ovatus Pompeckj, 1895, p. 517, pl. 14, fig. 4 (as *H. primus ovata*). M. Cambrian; Bohemia.

H. oxygonus (Novák), 1891, p. 32, pl. 1, figs. 1–11 (as *Ceratotheca oxygona*). Silurian; Bohemia.

H. oxys Clarke, 1907, p. 179, fig. L. Devonian; Quebec.

H. paishanensis Endo, 1937, p. 315, pl. 68, fig. 7. U. Cambrian; China.

H. pallidus Cobbold, 1931, p. 490, pl. 41, fig. 12. L. Cambrian; England.

H. paradoxus Eichwald, 1860, p. 1047, pl. 40, fig. 19. Ordovician; Esthonia.

H. parens Barrande, 1867, p. 87, pl. 10, figs. 7–16. M. Cambrian; Bohemia.

H. partitus Resser, 1938b, p. 46, pl. 16, fig. 20. M. Cambrian; Alabama.

H. parviusculus (Hall), 1862a, p. 55, fig. 10 (as *Theca parviuscula*). U. Ordovician; Wisconsin.

H. parvulus Girty, 1926, p. 38, pl. 6, figs. 18, 19. Mississippian; Texas.

H. pauper Barrande, 1867, p. 88, pl. 13, figs. 36–40. L. Devonian; Bohemia.

H. pauxillus Novák, 1891, p. 22, pl. 4, figs. 1–7. L. Ordovician; Bohemia.

H. paxillosus Novák, 1891, p. 23, pl. 4, figs. 13–22. Silurian; Bohemia.

H. penkillensis Reed, 1909, p. 209, pl. 2, figs. 3–5. L. Silurian; Scotland.

H. pennatuloides Cobbold & Pocock, 1934, p. 336, pl. 40, figs. 24, 25. M. Cambrian; England.

H. pennatulus Holm, 1893, p. 105, pl. 5, figs. 1–6; pl. 6, figs. 21, 22. M. Cambrian; Sweden.

H. (*O.*) *penultimus* (Hicks), 1872, p. 180, pl. 7, figs. 15, 16 (as *Theca penultima*). U. Cambrian; Wales.

H. peracuminatus (Haupt), 1878, p. 64, pl. 4, fig. 18 (as *Theca peracuminata*). Ordovician; Germany.

H. (*O.*) *peracutus* Holm, 1893, p. 66, pl. 2, figs. 17–19. Silurian; Sweden.

H. pinniformis Ruedemann, 1912, p. 111, pl. 7, figs. 12, 13. M. Ordovician; New York.

H. (*O.*) *plicatus* Brögger, 1878, p. 61, pl. 4, fig. 15 (as *H. plicatus*). Cambrian; Norway.

H. poulseni Resser, 1938a, p. 22. L. Cambrian; Greenland.

H. primaevus Groom, 1902, p. 116, figs. 17–24. Cambrian; England.

H. primordialis (Hall), 1861, p. 48 (as *Theca primordialis*). U. Cambrian; Wisconsin.

H. primus Barrande, 1867, p. 88, pl. 10, fig. 1, 2; pl. 11, figs. 26–28. M. Cambrian; Bohemia.

H. princeps Billings, 1872, p. 216, fig. 4. M. Cambrian; Quebec.

H. principalis Hall, 1876, pl. 27, figs. 17–20. M. Devonian; New York.

H. prolixus Resser, 1939a, p. 24, pl. 2, figs. 1–3. M. Cambrian; Idaho.

H. pumilus Ruedemann, 1926, p. 77, pl. 10, figs. 5, 6. U. Ordovician; New York.

H. (*O.*) *quadrangularis* Holm, 1893, p. 66, pl. 6, figs. 1–5. L. Ordovician; Sweden.

H. (*O.*) *quadricostatus* (Shaler & Foerste), 1888, p. 31, pl. 2, fig. 15 (as *H. quadricostatus*). L. Cambrian; Massachusetts.

H. rarus Howell, 1937, p. 1160, pl. 2, fig. 3. M. Cambrian; Vermont.

H. recidivus Holm, 1893, p. 99, pl. 2, figs. 8–11 (as *H. latus recidivus*). L. Ordovician; Sweden.

H. resseri Howell, 1946, see page 71. L. Cambrian; Virginia.

H. reversus (Salter), 1854, p. 550, pl. 10, fig. 21 (as *Theca reversa*). M. Ordovician; Wales.

H. rhenanus Mauz, 1933, p. 280, figs. 23, 24. Devonian; Germany.

H. rhine Ruedemann, 1901, p. 36, pl. 2, figs. 12–15. M. Ordovician; New York.

H. richardi Clarke, 1907, p. 179, figure. L. Devonian; Quebec.

H. richteri Geinitz, 1861, p. 44, pl. 12, fig. 2. Permian; Germany.

H. rimulosus (G. & F. Sandberger), 1855, p. 245, pl. 21, fig. 6 (as *Pugiunculus rimulosus*). Devonian; Germany.

H. robustus Barrande, 1867, p. 89, pl. 10. figs. 17–21. M. Cambrian; Bohemia.

H. roemeri Koenen, 1879, p. 321, pl. 7, fig. 1. Carboniferous; Germany.

H. (*O.*) *rosmarus* Holm, 1893, p. 64, pl. 1, figs. 41–46. L. Ordovician; Sweden.

H. rugosus Matthew, 1899, p. 194, pl. 3, fig. 4. L. Cambrian; Newfoundland.

H. rugulosus (Richter), 1865, p. 370, pl. 11, figs. 4, 5 (as *Cleodora rugulosa*). Devonian; Germany.

H. rusticus Barrande, 1867, p. 89, pl. 15, figs. 32, 33. L. Ordovician; Bohemia.

H. sandalinus Barrande, 1867, p. 90, pl. 12, figs. 7–12. L. Devonian; Bohemia.

H. sardous Vinassa de Regny, 1927, p. 451, pl. 2, fig. 6. Ordovician; Sardinia.

H. (*O.*) *sárkaënsis* (Novák), 1891, p. 44, pl. 2, figs. 10–13 (as *O.? sárkaënsis*). Ordovician; Bohemia.

H. scalprum Holm, 1893, p. 96, pl. 2, figs. 46–50. U. Ordovician; Sweden.

H. scanicus Moberg & Grönwall, 1909, p. 48, pl. 3, figs. 1–4. Silurian; Sweden.

H. schencki Ulrich, 1892, p. 37, pl. 3, fig. 9. Devonian; Bolivia.

H. sculptilis Cobbold, 1920, p. 356, pl. 24, figs. 25–27 (as *H.? sculptilis*). L. Cambrian; England.

H. searsi Grabau, 1900, p. 649, pl. 32, fig. 5. L. Cambrian; Massachusetts.

H. secans Barrande, 1867, p. 90, pl. 13, figs. 27–30. M. Devonian; Bohemia.

H. sericeus (Matthew), 1886, p. 55, pl. 6, fig. 7 (as *Diplotheca acadica sericea*). Cambrian; New Brunswick.

H. shaleri Walcott, 1884, p. 44, pl. 7, fig. 4. L. Cambrian; Massachusetts.
H. sicala Koninck, 1883, p. 224, pl. 54, figs. 12–15. Carboniferous; Belgium.
H. signatulus Novák, 1891, p. 23, pl. 4, figs. 37–39. M. Cambrian; Bohemia.
H. similis Walcott, 1890, p. 38. L. Cambrian; Newfoundland.
H. simplex (Barrande), 1847, p. 556, pl. 4, fig. 1 (as *Pugiunculus simplex*). Silurian; Bohemia.
H. simplex (Salter), 1866, p. 352, pl. 11B, figs. 22–26 (as *Theca simplex*). L. Ordovician; England.
H. singulus Hall, 1879, p. 202, pl. 32A, fig. 27. M. Devonian; New York.
H. socialis Linnarsson, 1873, p. 793, pl. 16, figs. 10–12. M. Cambrian; Sweden.
H. solitarius Barrande, 1867, p. 92, pl. 13, figs. 34, 35. Ordovician; Bohemia.
H. sondai Resser & Endo, 1937, p. 147, pl. 20, figs. 2, 3. L. Cambrian; China.
H. spryi Chapman, 1904, p. 340, pl. 31, fig. 9. Silurian; Victoria.
H. stiletto (Hicks), 1872, p. 180, pl. 7, figs. 18, 19 (as *Theca stiletto*). M. Cambrian; Wales.
H. strettonensis Cobbold, 1920, p. 355, pl. 24, figs. 30, 31. L. Cambrian; England.
H. striatellus Holm, 1893, p. 88, pl. 5, figs. 54, 55. U. Ordovician; Sweden.
H. (*O.*) *striatosulcatus* Chiesa, 1931, p. 229. Miocene; Libya.
H. striatulus (Barrande), 1847, p. 557, pl. 4, fig. 2 (as *Pugiunculus striatulus*). Ordovician; Bohemia.
H. striatus (Boll), 1859, p. 162 (as *Theca striata*). Ordovician; Germany.
H. striatus Eichwald, 1860, p. 1046, pl. 40, fig. 15. Ordovician; Esthonia.
H. striatus (Ludwig), 1864, p. 322, pl. 50, fig. 24 (as *Cleodora striata*). Devonian; Germany.
H. striatus Hall, 1876, pl. 27, figs. 8, 9, 12. M. Devonian; New York. (Name replaced by *H. halli* Sinclair, new name.)
H. striatus (Haupt), 1878, p. 64, pl. 4, fig. 17 (as *Theca striata*). Ordovician; Germany.
H. (*O.*) *striatus* Cobbold, 1920, p. 357, pl. 24, fig. 11 (as *H.* (*O.*) *bayonet striatus*). L. Cambrian; England.
H. sturi Klebelsberg, 1912, p. 509, pl. 22, figs. 21–26. Carboniferous; Austria.
H. (*O.*) *stylus* Holm, 1893, p. 52, pl. 1, figs. 16–20; pl. 6, figs. 6–9. M. Cambrian; Sweden.
H. subaequalis (Salter), 1845, p. 215, figs. 3, 4 (as *Theca subaequalis*). Devonian; South Africa.
H. subcarinatus Kobayashi, 1935, p. 73, pl. 3, figs. 19–22. U. Cambrian; Korea.
H. subcrispatus Reed, 1909, p. 209, pl. 2, figs. 6–8. U. Ordovician; Scotland.
H. (*O.*) *subexcavatus* Reed, 1909, p. 211, pl. 2, figs. 10–12. M. Ordovician; Scotland.
H. subimbricatus Ringueberg, 1888, p. 135, pl. 7, fig. 7. M. Silurian; New York.
H. (*O.*) *subornatus* Reed, 1909, p. 212, pl. 2, figs. 13–15. U. Ordovician; Scotland.
H. (*O.*) *subula* (Novák), 1891, p. 43, pl. 2, figs. 5–9 (as *O. subula*). Silurian; Bohemia.
H. sulcatulus Novák, 1891, p. 26, pl. 3, figs. 22–24. Ordovician; Bohemia.
H. sulcatus Reed, 1902, p. 125, pl. 6, fig. 4. U. Cambrian; Wales.
H. superstes Novák, 1891, p. 26, pl. 5, figs. 10–13. U. Devonian; Bohemia.
H. sylvestris Reed, 1909, p. 210, pl. 2, fig. 9. L. Silurian; Scotland.
H. tardus Barrande, 1867, p. 93, pl. 6, figs. 17, 18. M. Devonian; Bohemia.
H. tenuis Resser & Endo, 1937, p. 153, pl. 29, figs. 2, 4, 7. M. Cambrian; China.
H. tenuistriatus Linnarsson, 1873, p. 792, pl. 16, figs. 4–9. M. Cambrian; Sweden.
H. (*O.*) *teres* (Barrande), 1867, p. 93, pl. 10, figs. 3–6 (as *H. teres*). L. Ordovician; Bohemia.
H. teretapex Saito, 1936, p. 362, pl. 3, figs. 24–31. L. Cambrian; Korea.
H. (*O.*) *teretiusculus* (Linnarsson), 1877, p. 373, pl. 15, fig. 11 (as *H. teretiusculus*). M. Cambrian; Sweden.
H. terranovicus Walcott, 1890, p. 37. L. Cambrian; Newfoundland.
H. textilis Holm, 1893, p. 82, pl. 3, figs. 31–35. L. Ordovician; Sweden.
H. (*O.*) *thraivensis* Reed, 1909, p. 212, pl. 2, figs. 16–23. U. Ordovician; Scotland.
H. triadicus Gugenberger, 1934, p. 192 (as *H.? triadicus*). Triassic; Austria.
H. triangularis (Portlock), 1843, p. 375, pl. 28A, fig. 3 (as *Orthoceras triangularis*). U. Ordovician; Ireland.
H. triangularis (Hall), 1847, p. 313, pl. 87, fig. 1 (as *Theca triangularis*). M. Cam-

brian; New York. (Name replaced by *H. americanus* Billings, 1872.)

H. trilineatus Reed, 1902, p. 126, pl. 6, fig. 5. U. Cambrian; Wales.

H. (*O.*) *trinucleorum* Holm, 1893, p. 67, pl. 5, figs. 79–87. U. Ordovician; Sweden.

H. triliratus Hall, 1879, p. 201, pl. 32A, figs. 20–22. M. Devonian; New York.

H. triumvir Holm, 1893, p. 106, pl. 5, figs. 7–11. L. Ordovician; Sweden.

H. undulatus (Barrande), 1847, p. 558, pl. 4, fig. 4 (as *Pugiunculus undulatus*). U. Ordovician; Bohemia.

H. unguiformis (G. & F. Sandberger), 1855, p. 244, pl. 21, fig. 4 (as *Pugiunculus unguiformis*). Devonian; Germany.

H. unguiformis (Novák), 1891, p. 33, pl. 1, figs. 23–25 (as *Ceratotheca unguiformis*). Silurian; Bohemia.

H. uralicus Karpinsky, 1884, p. 15, figs. 9–14. Devonian; Russia.

H. vaginati (Quenstedt), 1851, p. 398, pl. 35, fig. 35 (as *Theca vaginati*). Ordovician; Russia. (*fide* Barrande. Holm gives the date as 1852, and the name as *Pigiunculus vaginati*. I have not seen this edition of Quenstedt.)

H. vaginula (Salter), 1866, p. 352, pl. 10, fig. 14 (as *Theca vaginula*). M. Ordovician; Wales.

H. (*O.*) *vanuxemi* (Walcott), 1884a, p. 85, pl. 11, fig. 16 (as *H. vanuxemi*). L. Ordovician; Nevada.

H. ventricosus (Ludwig), 1864, p. 323, pl. 50, fig. 26 (as *Cleodora ventricosa*). Devonian; Germany.

H. venustus Barrande, 1867, p. 95, pl. 9, figs. 14, 15. M. Cambrian; Bohemia.

H. versaillesensis Miller & Faber, 1894, p. 155, pl. 8, figs. 20–22. U. Ordovician; Indiana.

H. vitraeus (Rouault), 1851, p. 361 (as *Theca vitraea*). L. Ordovician; France.

H. vomer Holm, 1893, p. 83, pl. 5, figs. 34–41; pl. 6, fig. 27. L. Ordovician; Sweden.

H. walcotti Howell, 1946, see page 71. U. Cambrian; Nevada.

H. wanneri Resser & Howell, 1938, p. 215, pl. 4, figs. 4–9. L. Cambrian; Virginia.

H. welleri Roy, 1929, p. 208, pl. 35, fig. 3. L. Cambrian; New York.

H. whitei Resser, 1938a, p. 21. L. Cambrian; Nevada.

H. willsi Cobbold, 1919, p. 152, pl. 4, figs. 17, 18. L. Cambrian; England.

H. wynnei Waagen, 1885, p. 781, fig. 25. Cambrian; India.

NAMES USED FOR ORTHOTHECA

The following species have been described as *Orthotheca* and apparently never referred to *Hyolithes*. They are not so referred now, and the names will be available if *Orthotheca* is considered to have generic rank.

O. acicula Howell, 1937, p. 1160, pl. 2, fig. 4; pl. 4, fig. 29. M. Cambrian; Vermont.

O. barrandei Novák, 1891, p. 37, pl. 2, figs. 23–26. Devonian; Bohemia.

O. corrugata Matthew, 1899b, p. 42, pl. 1, fig. 3. U. Cambrian; British Columbia.

O. cylindrica Grabau, 1900, p. 654, pl. 32, fig. 8. L. Cambrian; Massachusetts.

O. daulis Walcott, 1905, p. 20. M. Cambrian; China.

O. doris Walcott, 1905, p. 21. M. Cambrian; China.

O. dubia Howell, 1937, p. 1161, pl. 2, fig. 6. M. Cambrian; Vermont.

O. foerstei Grabau, 1900, p. 657, pl. 32, fig. 10 (as *O.? foerstei*). L. Cambrian; Massachusetts.

O. interstrialis Novák, 1891, p. 40, pl. 3, figs. 29–35. Silurian; Bohemia.

O. lamellosa Novák, 1891, p. 40, pl. 2, figs. 14–18; pl. 4, fig. 23–26. Devonian; Bohemia.

O. major Walcott, 1908, pl. 1, fig. 11. M. Cambrian; British Columbia.

O. pugio Matthew, 1899, p. 193, pl. 2, fig. 4. L. Cambrian; Newfoundland.

O. pyramidata Novák, 1891, p. 42, pl. 2, figs. 19–22. Devonian; Bohemia.

O. quadricostata Novák, 1891, p. 42, pl. 3, figs. 16–21. Silurian; Bohemia. (Not *H.* (*O.*) *quadricostatus* (Shaler & Foerste), 1888.)

O. sica Matthew, 1899, p. 193, pl. 2, fig. 5. L. Cambrian; Newfoundland.

O. sola Resser, 1939, p. 7, pl. 1, fig. 33 (as "*O.*" *sola*). M. Cambrian; Idaho.

O. steinmanni Knod, 1908, p. 518, pl. 23, figs. 5, 6; pl. 31, fig. 4. Devonian; Bolivia.

O. stiletto Matthew, 1899, p. 193, pl. 2, fig. 3. L. Cambrian; Newfoundland.

O. ultima Novák, 1891, p. 44, pl. 2, figs. 36–40. U. Devonian; Bohemia.

O. vermontensis Howell, 1937, p. 1161, pl. 2, fig. 5. M. Cambrian; Vermont.

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JOURNAL OF PALEONTOLOGY, VOL. 20, NO. 1, PP. 86–87, 2 TEXT FIGS., JANUARY 1946

PERMIAN(?) BRYOZOA FROM SUSTUT LAKE, BRITISH COLUMBIA

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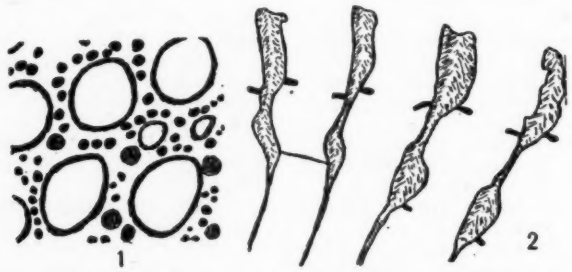
THE study of a small collection of Bryozoa from near Sustut Lake in north-central British Columbia, collected in the summer of 1944 by C. S. Lord of the Geological Survey of Canada, provides evidence to show that certain limestones at that locality may be of Permian age.

This limestone contains numerous bryozoan fragments, which are firmly embedded in the matrix. Satisfactory microscopic sections have been obtained of only one species. This species belongs to the genus *Tabulipora*, which ranges from the Mississippian to the Permian. Aside from the numerous species described by Lee (1912) this genus is little known. *Tabulipora carbonaria* (Worthen, 1875) is recorded from the Pennsylvanian of Ohio, Illinois, Kansas, and northern Mexico. *Tabulipora tenuinervis* Bassler (1929) has been described from the island of Timor. The species *Tabulipora sustutensis*, described in this paper, shows its closest affinities with the latter form. Further relationship with the Timor fauna is revealed by the presence of a species of *Fistulipora* which, unfortunately, is too poorly preserved to accurately describe.



FIGS. *1*, *2*—*Tabulipora sustutensis* Fritz, n. sp. *1*, Tangential section 8771c, ×33; *2*, vertical section of mature region, 8771d, ×33. Both sections from holotype, Geological Survey collection, National Museum Canada. ?Permian, Sustut Lake, north-central British Columbia, Canada.

TABULIPORA SUSTUTENSIS Fritz, n. sp.
Figures 1, 2

External features.—The zoarium consists of apparently smooth branches with a diameter of 5 to 6 mm. Cross cuts of the branches show that the zooecia in the central region are uniformly rhomboidal in outline, giving the axis a characteristic appearance.

Tangential section.—At the surface the zooecial apertures are round to oval in outline with an average of five in 2 mm. measured on the longer axis. The apertures are apt to be irregular in size and shape as the surface is approached owing to the marked development, throughout the mature region, of periodically developed laminated tissue. The actual walls of the zooecia are thin. Mesopores are present but not common. Small acanthopores are numerous and irregularly disposed in the interzooecial tissue. Associated are larger acanthopores with solid centres, two or three being located about a zooecium.

Vertical section.—In the axial region the zooecial walls are thin and straight. Diaphragms in this portion are infrequent. The tubes curve gradually outwards to the peripheral region, where laminated tissue of an irregular beadlike character develops. Within this beaded zone perforated diaphragms make their appearance, as well as a few complete diaphragms.

Remarks.—From the Timor species *T. tenuinervis*, *T. sustutensis* may be distinguished by the smaller size of its branches, the absence of groups of larger zooecia, and

by the less extravagant development of irregularly laminated tissue.

Holotype.—Geological Survey Collections, National Museum Canada, no. 8771; paratypes, 8771a, 8771b. Microscopic slides 8771c, 8771d.

Occurrence.—?Permian, Sustut Lake, north-central British Columbia, Canada.

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A RHOPALONARIA IN THE DUNDAS FORMATION AT TORONTO

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ALTHOUGH the Bryozoa of the Dundas formation of the Upper Cincinnatian series in southeastern Ontario have been studied in considerable detail (Armstrong, 1945, Fritz, 1926, Parks and Dyer, 1921), no examples of the Ctenostomata have been hitherto reported. However, during a recent visit to the Don Valley Brickyard in Toronto, W. W. Weber, a student in geology at the University of Toronto, found fragments of two pelecypod shells (possibly *Modiodesma modiolare*) marked by excavations that represent the delicate threadlike stolons and the somewhat more robust internodes of a species of *Rhopalonaria*. The shells were in the Danforth member of the Dundas formation. They are catalogued as numbers 26217 and 26218 in the Royal Ontario Museum of Palaeontology.

Because of imperfect preservation and subsequent weathering, the primary disposition of the zoarial elements is obscured, but the delicate structures appear to have a right-angled arrangement. If this be the case, the pattern of the zoarium might be like that of the genotype, *Rhopalonaria venosum*, from the Lorraine and Richmond of Ohio and Indiana. Until better material becomes available, no specific identification can be made nor a fuller description given.

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HYOLITHES COOPERI, NEW NAME

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In 1935 (Geol. Soc. America Bull., vol. 46, p. 851, pl. 60, figs. 21, 25) I described a new fossil from the West Brook member of the Devonian Tully formation as *Hyolithes inaequistriatus*. Since this name had been used by Remelé in 1888 I now propose for the Tully species the new name *Hyolithes cooperi* Williams. The cotypes are in the United States National Museum, numbers 89741 and 89741a, and were found at West Brook, New York.

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CORRECTIONS TO "NEW UPPER CAMBRIAN TRILOBITES FROM THE LÉVIS CONGLOMERATE"

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In a paper bearing the above title[1] the writer described a number of new species of Cambrian trilobites resulting from the study of collections loaned by the United States National Museum. It was then believed that these specimens were all property of the Museum, and hence the types were designated by U. S. National Museum catalogue numbers.

However, while the paper was in press it was ascertained that much of the material in question had been loaned to Dr. Ulrich from the Geological Survey of Canada, and was property of the Survey. This part of the material was returned to the Geological Survey of Canada, and with it went several of the types of new species described by the writer. Hence it becomes necessary to change the data regarding the types of some of the species.

The accompanying table gives all the changes that must be effected. Type designations of specimens not mentioned in the table stand as given in the paper. The writer is indebted to Dr. G. Arthur Cooper and Dr. Alice E. Wilson for supplying the data for these corrections.

[1] RASETTI, F., 1945, New Upper Cambrian Trilobites from the Lévis Conglomerate: Jour. Paleontology, vol. 19, no. 5, pp. 462–478.

[2] This specimen was described in RASETTI, F., 1945, Evolution of the facial sutures in the trilobites *Loganopeltoides* and *Loganopeltis:* Am. Jour. Sci., vol. 243, pp. 44–50.

Species	Type	Former type designation U.S.N.M. Cat. No.	Corrected type designation G.S.C. Cat. No.
Apatokephaloides rotundatus Rasetti	Holotype	111700	7667
Apatokephaloides rotundatus Rasetti	Paratype	111701	7667a
Bayfieldia ulrichi Rasetti	Holotype	111702	7660
Bayfieldia ulrichi Rasetti	Paratypes	111703, a-c	7660a–d
Bellaspidella latifrons Rasetti	Holotype	111707	7671
Bellaspidella latifrons	Paratypes	111708, a	7671a, b
Bellaspidella resseri Rasetti	Holotype	111704	7679
Bellaspidella resseri Rasetti	Paratypes	111705, a	7679a, b
Glyptometopus laflammei (Clark)	Plesiotype	111728	7662
Keithiella cylindrica (Billings)	Plesiotype	111730	7668
Keithiella maior Rasetti	Holotype	111717	7666
Levisella oweni (Billings)	Plesiotype	111722	7663
Loganopeltoides zenkeri (Billings)	Plesiotype[2]	111725	7685
Onchonotus? sedgwicki (Billings)	Plesiotype	111726	7669
Onchonotus? sedgwicki (Billings)	Plesiotype	111727	7670
Parabolina? incerta Rasetti	Holotype	111720	7659
Phoreotropis? marginata Rasetti	Holotype	111711	7661
Phoreotropis? marginata Rasetti	Paratypes	111712, a-c	7661a–d
Platydiamesus depressus Raymond	Plesiotype	111729	7680
Platydiamesus levisensis Rasetti	Plesiotype	111724	7664
Tatonaspis levisensis Rasetti	Plesiotype	111723	7665

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